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AN

ELEMENTARY AND PRACTICAL

ARITHMETIC,

IN WHICH HAVE BEEN ATTEMPTED

VARIOUS IMPROVEMENTS

IN ARRANGEMENT AND NOMENCLATURE,

AS WELL AS IN THE MEANS OF SECURING

THOROUGH DISCIPLINE

IN THE PRINCIPLES AND APPLICATIONS OF THE SCIENCE.

BY JAMES B. DODD, A. M.,
Morrison Professor of Mathematics and Natural Philosophy, in
Transylvania University; late Professor of Mathematics, &c.,
in the Centenary College of Louisiana.

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PREFACE.

In this work an effort has been made to treat the subject of Arithmetic with that strictness of method which is appropriate to the nature of every branch of mathematical science.

By a *new arrangement* of several subjects, consequent upon a regard to what has seemed the most natural order of instruction, a wider range of application has been assigned to general Rules. Decimal Fractions, for example, include Federal Money; and the Reduction of quantities to different denominations, whether Integers, Vulgar Fractions, or Decimals,—usually forming three divisions of Arithmetic, requiring half a dozen Rules,—is presented under two consecutive Rules in Reduction descending, and ascending. Other simplifications in the structure of the work, will be noticed by the intelligent Arithmetician, and need not be here specified. They will all be found to facilitate the acquisition of the science, in the only way in which any science can be effectually acquired—by apprehending its general principles, and carrying those principles into their particular applications.

Some *changes in nomenclature* have been introduced, from a belief, strengthened by the concurring opinions of numerous literary and scientific friends of the author, that such changes would be useful, and would thus be likely to succeed. For "*denominate number*," applied to such an expression as 3 *bushels* of grain, for example, is substituted *monomial* quantity, or simply *monomial:* and for "*compound number*," or "*compound denominate number*," applied to such an expression as 3 *bu.* 2 *pk.* 5 *qts.* of grain, is used *polynomial* quantity; or simply *polynomial*. These terms, *monomial* and *polynomial*, are literally appropriate to the designation of the quantities to which they are thus applied; and, having the advantage of greater brevity and precision than those for which they are substituted, they will be found to introduce real improvements in the composition of the Rules relating to such quantities.

"*Partnership,*" or "Fellowship," is superseded by *Partitive Proportion.* Of the two former terms the first is properly a *commercial,* the second a *moral* term : neither of them is significant of any arithmetical principle or operation. Partitive Proportion is properly, and in a general sense, descriptive of Proportion applied to dividing a given quantity into two or more *parts* which shall have a given *ratio,* one to another ; and such is the purpose to be effected in all questions falling under this division of Arithmetic. "*Alligation*" is superseded by *Medial Proportion.* The former designation refers to the mere expedient of drawing a line between two numbers entering into a calculation; and expresses nothing as to the nature of the arithmetical subject to which it is applied. In the treatment of Alligation, so called, the primary purpose, on which all others peculiar to the subject depend, is, to assign the *ratios* of two quantities, at different rates of value, for a compound of a given *medial* or *mean* rate of value. This is effected by the simplest application of *Inverse* Proportion ; and the term Medial Proportion, as defined in this treatise, with the accompanying Rule, places the subject in connection with the scientific principle on which it primarily depends.

Various *minor changes* in phraseology will be noticed in different parts of the present work. Wherever it was conceived that, by this means, any thing could be gained on the score of precision or distinctness in the presentation of any particular subject, new terms or modes of expression have been employed ; and, in a few instances, the more perfect language of the higher mathematics has been put under contribution to these ends. As an example of the latter, may be mentioned "*Variation* or *General Proportion.*" The very brief sketch of this subject has been given because the phraseology appropriate to it is convenient in stating the proportions of quantities, in a general way ; particularly in distinguishing between *direct* and *inverse* Proportion. And here it may be necessary to remark that Inverse Proportion has been somewhat minutely treated on account of the use which is made of it in the higher applications of Proportion—notwithstanding its entire omission in many Arithmetics, as well as in Algebras and Geometries.

In *range of subjects,* this work embraces what has been considered a proper course of Arithmetical instruction and exercise for schools ; all that is necessary to a business education, so far as this science is concerned ; and certainly all that can be advantageously assigned to this department, in a regular course of mathematical studies. Whatever subjects, treated in similar works, are omitted in this, have been omitted from the consideration of their inutility for business purposes,—from the calculations which they require being fully provided for by the Principles and Rules here given,—from a regard to the superior facility with which they are treated in Algebra, now generally introduced into respectable schools,—or, because depending on the principles of Geometry, they cannot be presented satisfactorily in Arithmetic.

The *practical exercises*, it is hoped, will be found sufficiently numerous, and well adapted to the purpose intended. They have been prepared with studious care, and with special reference to disciplining the mind of the student in the principles and applications of the science. Commencing always with the most simple that can be presented under each Rule, they advance gradually to the more complex,—to such as seem fitted to excite the reflections and reasonings of the student, without which, it should ever be remembered, but little intellectual cultivation can be secured. In the earlier stages of education, it is by *exercises* rationally performed, more than by demonstrations of abstract propositions in science, that the intellectual faculties are to be awakened to invigorating efforts; and this consideration has been kept constantly in view in the requisitions made upon the student in the arithmetical course here given.

As the result of much experience in teaching, in every grade of schools, from the lowest to the highest,—and of long continued, anxious labor in its preparation, before its different parts could be reduced to such *system* and *simplicity* as would please himself,—the author submits this work to the judgment of his fellow laborers in the great field of education, fully sensible how much its success will depend on their favorable opinions.

To several distinguished teachers, by whom the work was examined in the manuscript, the author is under obligations for encouragement and aid. What he considers one of its most valuable features, is due to the suggestions of *Maj. Thales Lindsley*, of the Faculty of the Kentucky Collegiate and Military Institute; recently a member of the Faculty of Transylvania University: and to *Mr. William Tufts, Jr.*, a member of the graduating class in the latter institution, the work is largely indebted for the accuracy which is believed to have been attained in its final revision.

TRANSYLVANIA UNIVERSITY, JUNE 28TH, 1849.

REMARKS ON THE MOST CONVENIENT AND EFFECTUAL METHOD OF USING THIS WORK.

1. The *Analysis of Contents* presents the topics to be noticed by the Teacher, in an oral examination on the *explanatory*, *preceptive*, and *demonstrative* parts of the book. The student will prepare himself by mastering the subjects referred to by the figures in the *parentheses*, which correspond with the series §1, §2, §3, &c., in the body of the work—and the *demonstrations* included between the ☞ ☜.

The Teacher will however be able to proceed with such examination, without using the Analysis, except for convenience in reviewing considerable portions of the work at once.

2. The oral exercises on Definitions, or principles preliminary to the Rules, should be required; and may easily be carried to greater length, at the discretion of the Teacher.

3. The *Examples* immediately following the Rules, carefully studied by the learner, will generally supersede the necessity of explanation from the Teacher.

4. The Operation inculcated by the Rule being fully mastered,—before entering on the practical *Exercises* with his slate, let the learner read each question, and give a *verbal, explanatory* solution, according to the principles involved, as exemplified for numerous questions in different parts of the work. This will require him to reason out the solution before commencing his numerical operation; and will thus *obviate the objections* urged by many against furnishing him with the *answers* to the questions. The Teacher will judge on what parts of the work this method may be advantageously employed.

5. The *Exercises on Chapter II*, *Chapter III*, and so on through the book, involve all the operations belonging to the particular Chapter, and may be used, at any time, for review and examination. Being somewhat more complex than those connected with the separate Rules, the Teacher will judge in what cases it might be best to omit them in first going through the book. These Exercises, in connection with the Analysis of Contents, will afford peculiar facilities for general examinations, *oral* and *operational*.

ANALYSIS OF CONTENTS.

This Analysis is designed to be used in an oral examination, in review. The Teacher will name the *topic* as presented in this table: the Learner will respond according to his knowledge of the subject.

For example; the Teacher will say "Arithmetic;" the Learner will respond "Arithmetic is the science of Numbers; or, when practically applied, the art of Calculation."

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POWERS AND ROOTS.

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ARITHMETIC.

CHAPTER I.

PRELIMINARY DEFINITIONS.—NUMERATION.—NOTATION.

Science and Art.

§ **1.** SCIENCE is knowledge reduced to a *system*, so as to be conveniently taught, and readily applied.—ART is knowledge applied to practical purposes.—The Rules of art are founded on the Principles of science.

Unity and Numbers.—Quantity.

§ **2.** A *Unit* is any thing regarded simply as *one;* and *Numbers* are *repetitions* of a unit.

The numbers *two, three,* &c., are repetitions of a *unit* or one.

§ **3.** *Quantity* is any thing which admits of being *measured.*

Thus a *line* is a quantity, and we express its *measure* when we say it is so many *feet* or *inches* long.

Is *time* a quantity? Is *industry* a quantity? Is *weight* a quantity?
Is *hope* a quantity? Is *distance* a quantity? Is *virtue* a quantity?
Are *length, breadth,* and *height* quantities?

Numbers are quantities, since every number is necessarily measured by a *unit,* (§ 2); and numbers are necessary to express the measures of all other quantities.

Thus we express the measure of a quantity of water by saying it is *five gallons;* and the measure or weight of a quantity of iron by saying it is *ten pounds.*

PRELIMINARY DEFINITIONS.

§ **4.** MATHEMATICS is the science of Quantity. Its most general divisions are Arithmetic and Geometry.

ARITHMETIC is the science of Numbers; or, when practically applied, the art of Calculation.—GEOMETRY is the science which treats of Extension, including *length, breadth,* and *height* or *depth.*

Of these two divisions of mathematical science, Arithmetic comes first in order; and we begin by distinguishing different kinds of numbers.

Abstract and Concrete Numbers.

§ **5.** An *abstract* number is a number without any *kind of units* expressed; as the numbers *one, five, ten,* a *hundred.*

§ **6.** A *concrete* number is a number of *some kind* of units expressed; as the numbers *one* book, *five* men, a *hundred* dollars.

Is *twenty* an abstract or a concrete number? Is *nine* pounds an abstract or a concrete number? *One hundred? Two hundred* miles?

Give two other examples of abstract, and two of concrete numbers.

Similar and Dissimilar Numbers.

§ **7.** *Similar* concrete numbers are such as express the *same kind* of units; as *three* dollars and *five* dollars.

§ **8.** *Dissimilar* concrete numbers are such as express *different kinds* of units; as *three* dollars and *five* miles.

Are *four* inches and *seven* inches, similar or dissimilar concrete numbers? *Nine* pounds and *twelve* yards? One cent and *ten* pints?

Give another example of *similar* concrete numbers. Of *dissimilar* concrete numbers. Give another example of each kind.

The groundwork of a thorough knowledge of Arithmetic must be laid in the principles of Numeration and Notation; for on these principles depend the four fundamental operations in Arithmetic—Addition, Subtraction, Multiplication, and Division.

NUMERATION.

§ **9.** NUMERATION is the method of *naming* abstract numbers. Numbers are named as so many *units, tens, hundreds,* &c.

Thus *eleven* is *one* and *ten;*
twelve is *two* and *ten;*
thirteen is *three* and *ten;*
seventeen is *seven* and *ten.*

Twenty is *two tens;*
twenty-five is *two tens* and *five;*
thirty-nine is *three tens* and *nine.*

A *hundred* is *ten tens;*
A *thousand* is ten hundred.

A *million* is ten hundred thousand, or a *thousand* thousands.
A *billion* is ten hundred millions, or a *thousand* millions.
A *trillion* is ten hundred billions, or a *thousand* billions.

In like manner Numeration proceeds through *quadrillions, quintillions, sextillions, septillions, octillions, nonillions, decillions, undecillions, duodecillions,* &c.

What two numbers are implied in the name *fourteen?* In the name *fifteen?* In *eighteen?* In fifteen? In seventeen?

What is implied in the name *twenty?* In the name twenty-one? In thirty? In forty? In fifty? Sixty? Seventy? Ninety?

A quadrillion is how many? A quintillion? A sextillion? A septillion? An octillion? A nonillion? A duodecillion?

Different Orders of Units.

§ **10.** The naming of numbers by *tens, hundreds,* &c., introduces different *orders of units* in Numeration.

The numbers *two, three, four,* &c., are repetitions of the simple unit *one,* which is called a *unit* of the *first order.*

Twenty, thirty, forty, &c., are, respectively, two *tens,* three *tens,* four *tens,* &c.; and in these repetitions of *ten, ten* is regarded as a *unit of the second order.*

So in repetitions of a *hundred,* as two *hundred,* three *hundred,* &c., *one hundred* is regarded as a *unit* of the *third order.*

In like manner, *one thousand* is made a *unit* of the fourth *order;* and so on.

In the number *Three hundred and forty-seven*, for example, we find *seven units* of the *first* order, *four* of the *second*, and *three* of the *third*.

In the number *Five thousand, nine hundred and four*, we find *four* units of the *first* order, *none* of the *second*, *nine* of the *third*, and *five* of the *fourth*.

How many *units* of the first and second *orders*, respectively, do you find in the number Twenty-five? In the number Thirty-one? In the number Seventy-six? In the number Nineteen? In the number Ninety-nine?

How many *units* of *distinct orders* are found in the number Five hundred and thirty-four? In the number Nine hundred and fifty-one? In Three thousand seven hundred and sixteen? In Eight thousand one hundred and seventy?

Scale of Numeration.

§ **11.** *Ten* of any *lower order* of units make *one* of the next higher order; or, *one* of a higher order makes *ten* of the next lower order.

Thus *ten units* (of the first order) make *one* ten.

How many Tens make One hundred? How many Hundreds make One thousand? How many Hundreds make Two thousand? How many Hundreds make Three thousand?

One million is how many Hundred thousand? One billion is how many Hundred millions? One trillion is how many Hundred billions?

Numeration Table.

§ **12.** The *ascending orders* of units are given from right to left, in the following Table:

Billions, &c.	*Hund. of mill.,*	*Tens of mill.,*	*Millions,*	*Hund. of thous.,*	*Tens of thous.,*	*Thousands,*	*Hundreds,*	*Tens,*	*Units,*

Recite the orders of units, *ascending*, from Units to Decillions. Recite them, *descending*, beginning with Hundreds. Beginning with Thousands. Beginning with Tens of thousands. Beginning with Hundreds of thousands. Beginning with Millions. Beginning with Billions.

What are the *relative values* of these different orders of units (§ 11)?

NOTATION.

§ 13. NOTATION is the method of *denoting* numbers by numeral characters or *figures*.

These Figures—sometimes called the *digits* of numbers—are 1 *one*, 2 *two*, 3 *three*, 4 *four*, 5 *five*, 6 *six*, 7 *seven*, 8 *eight*, 9 *nine*, and the 0 *zero* or *cipher*, which denotes *nothing*.

The figures from 1 to 9 inclusive, are *significant;* the 0 is *insignificant.*

Tens, Hundreds, &c.—how denoted.

§ 14. *Tens*, *hundreds*, &c., are denoted by *two*, *three*, &c., *figures* in a row, right and left,—the *first* on the *right* being *units*,—the *second*, *tens*,—the *third*, *hundreds*, and so on, according to the ascending orders of units. (§ 12.)

Thus 12, 1 *ten* and 2, that is, *twelve;*
123, 1 *hundred*, 2 *tens*, and 3; or *one hundred and twenty-three.*

What would be the value of 4 in the *first place* on the right? In the second place? In the third place? In the fourth place?

Simple and Local Values.

§ 15. The *simple* value of a figure is that which is expressed by the simple *name* of the figure—being its value when used *alone*, or in the units' place.

Thus the simple value of 5 is *five;*
and 5 has its simple value in 25, 2 *tens* and 5, or *twenty-five.*

§ 16. The *local* value of a figure is that which arises from its *place* in a row of figures—being its simple value increased *tenfold* for each place it is removed from *units* toward the left.

In 25, 2 has the local value 2 *tens*, which is 10 *times* the simple 2; and in 125, 1 has the local value 1 *hundred.*

3 in the second place from the right would be how many times the *simple* 3? In the third place? In the fourth place? In the fifth?

Use of 0 *Zero or Cipher.*

§ 17. The 0 *zero* or cipher, having no value, is used to occupy *vacant* places in notation; and thus to assign a required *local value* to another figure, by removing it the proper distance from the units' place.

Thus 10, 1 with a 0 occupying the *units'* place, denotes *Ten.*
so, 100, 1 with two 0s for *tens* and *units*, is *One hundred.*

How may the figure 2 be made to denote 2 *tens*, or *twenty?* How may it be made to denote 2 *hundred?* 2 *thousand?* 2 *millions?*

How may 3 be made to denote 3 hundred? 3 thousand? 30 thousand? 3 hundred thousand? 3 millions? 3 hundred millions?

RULES OF ARITHMETIC.

§ 18. A *Rule*, in Arithmetic, is a prescribed mode of performing an Arithmetical operation.

RULE I.

§ 19. *To Numerate or read a row of Figures.*

Call the successive figures *units, tens, hundreds*, &c., from *right to left* (§ 12), and then read them according to their respective names or values from *left to right.*

EXAMPLE.

To read the number

7 0 4 3 6 0 5 2 1

Calling the figures, one after another, *units, tens, hundreds*, &c., from right to left, we find the last figure 7 to be *hundreds of millions.* Then reading from left to right, we say,

Seven hundred and four millions, Three hundred and sixty thousand, Five hundred and twenty one.

EXERCISES.

Read each of the following numbers,—from the top to the bottom of each column.

1st,	11
2nd,	12
3rd,	13
4th,	16
5th,	19
6th,	20
7th,	21
8th,	30
9th,	34
10th,	40
11th,	49
12th,	100
13th,	205
14th,	300
15th,	473
16th,	510
17th,	701
18th,	900
19th,	1000
20th,	3800
21st,	24000
22nd,	37220
23rd,	40079
24th,	71003
25th,	89050
26th,	94376
27th,	100000
28th,	270270
29th,	341143
30th,	404404
31st,	1000000
32nd,	5400375
33rd,	7347531
34th,	20000000
35th,	34000000
36th,	75603740
37th,	80730783
38th,	300000000
39th,	473830731
40th,	380707349
41st,	701803909
42nd,	890760540
43rd,	4000000000
44th,	5738146839
45th,	9030707301

RULE II.

§ 20. *To write in Figures any given Number.*

Place proper figures from *left to right*, to denote the number in each of the *descending orders* of units, from the highest in the given number down to simple units; observing to fill each *vacant* place with a 0. (§ 17.)

EXAMPLE.

To write in figures the number

Three millions, twenty-five thousand, and thirty.

The descending orders of units in this number, are

3 *millions*, 2 *tens* of thous., 5 *thousands*, and 3 *tens*.

Hence we write it,

3025030;

in which the vacant places of *hundreds* of thousands, *hundreds*, and *units*, are filled with 0s.

EXERCISES.

Write in figures each of the following numbers:—

1. One hundred.
2. Two hundred and one.
3. Three hundred and ten.
4. Four hundred and five.
5. Five hundred and fifteen.
6. Six hundred and twenty.
7. Seven hund. and thirty-four.
8. Eight hundred and eleven.
9. Nine hund. and ninety-nine.

10. One thousand.
11. Two thousand and nine.
12. Five thousand and ten.
13. Seven thous. one hundred.
14. Three thousand and five.
15. Eight thous. and nineteen.
16. Nine thous. and eleven.
17. Four thousand, five hundred and seventy-eight.

18. Ten thousand.
19. Twelve thousand and ten.
20. Twenty thousand and nine.
21. Fifty-four thousand, one hundred and twenty-three.
22. Eighty-seven thousand, five hundred and seventy-eight.
23. Seventy-one thousand, two hundred and one.
24. Forty thousand, three hundred and two.

25. One hundred thousand.
26. Two hundred and thirty thousand, one hundred.
27. Five hundred and one thousand, two hundred and three.
28. Seven hundred and thirteen thous., four hundred and fifty.
29. Nine hundred and ninety-nine thousand, and one.
30. Eight hundred thousand, and seven hundred.
31. Nine hundred and one thousand, one hundred and nine.

32. One million.
33. Five millions, five hundred thousand.
34. Nineteen millions, two hundred and forty-seven thous.
35. Thirty millions, one hundred and fifty thousand, seven hundred.
36. Seventy-five millions, eight hundred and sixty-four thousand, nine hund. and twelve.
37. Eleven millions, seven hundred and fourteen thousand.
38. Twenty-nine millions, four hundred and one thousand, two hundred and ten.
39. Thirty millions, nine hundred and twenty thousand.
40. Seven millions, eighty-five thousand, six hundred and forty-nine.
41. Eighty-five millions, eighty-seven thousand, four hundred and ninety seven.
42. Ninety-nine millions, one hundred and eleven thousand, one hundred and one.
43. One hundred millions.
44. Three hundred millions, one hundred thousand.
45. Five hundred and thirty-four millions, nine hundred.
46. Six hundred and nine millions, fifty thousand, one hundred and twenty-five.
47. Nine hundred and seventeen millions, five hundred thous., four hundred and sixty.
48. Five hundred millions, sixty thousand, three hundred and four.
49. Seven hundred and ten millions, one hundred thousand, five hundred and ninety-one.
50. Three hundred and one millions, seven hundred and ten.
51. Eight hundred and six millions, nine hundred and nineteen thousand, one hundred.
52. Nine hundred and ninety-nine millions, nine hundred and ninety-nine thousand, nine hund. and ninety-nine.

French and English Numeration.

§ **21.** In the French system of Numeration, which prevails in continental Europe, and in America, a *thousand millions* make *one billion*, a *thousand* billions make *one trillion*, and so on (§ 9 and § 12).

In the English system, a *million millions* make *one billion*, a *million* billions make one *trillion*, and so on.

Hence, in this system, after *hundreds of millions*, the ascending order of units are, *thousands* of millions, *tens of thousands* of millions, *hundreds of thousands* of millions, *billions;* and in like manner after *hundreds of billions*, &c.

For example, the number 3 840 930 670 820, in the French system, is 3 *trillions*, 840 *billions*, 930 *millions*, 670 *thousand*, eight hundred and twenty.

In the English, it is 3 *billions*, 840930 *millions*, 670820.

CHAPTER II.

ADDITION. — SUBTRACTION. — MULTIPLICATION. — DIVISION.

ADDITION.

§ **22.** ADDITION consists in finding the *sum* or *aggregate* amount of two or more numbers.

Thus the *sum* of 4 and 5 is 9; or 5 *added to* 4 makes 9.

What is the *sum* of 7 and 3? Of 6 and 4? Of 8 and 5?

The Sum found may be regarded as a *whole,* of which the given numbers are the *parts.*

What is the *sum* of 4, 6 and 8? Then what is the *whole,* and what are its *parts*? What is the sum of 10, 4, and 3? Then what is the whole, and what are its parts?

§ **23.** The *whole* is equal to the *sum of all its parts.*

Recite the *elementary sums* of numbers; thus 1 and 1 are 2; 1 and 2 are 3; &c.—2 and 1 are 3; 2 and 2 are 4; &c., as given from left to right in the

Addition Table.

1 *and*	1 *are* 2	2 *are* 3	3 *are* 4	4 *are* 5	5 *are* 6	6 *are* 7	7 *are* 8	8 *are* 9	9 *are* 10
2 *and*	1 *are* 3	2 *are* 4	3 *are* 5	4 *are* 6	5 *are* 7	6 *are* 8	7 *are* 9	8 *are* 10	9 *are* 11
3 *and*	1 *are* 4	2 *are* 5	3 *are* 6	4 *are* 7	5 *are* 8	6 *are* 9	7 *are* 10	8 *are* 11	9 *are* 12
4 *and*	1 *are* 5	2 *are* 6	3 *are* 7	4 *are* 8	5 *are* 9	6 *are* 10	7 *are* 11	8 *are* 12	9 *are* 13
5 *and*	1 *are* 6	2 *are* 7	3 *are* 8	4 *are* 9	5 *are* 10	6 *are* 11	7 *are* 12	8 *are* 13	9 *are* 14
6 *and*	1 *are* 7	2 *are* 8	3 *are* 9	4 *are* 10	5 *are* 11	6 *are* 12	7 *are* 13	8 *are* 14	9 *are* 15
7 *and*	1 *are* 8	2 *are* 9	3 *are* 10	4 *are* 11	5 *are* 12	6 *are* 13	7 *are* 14	8 *are* 15	9 *are* 16
8 *and*	1 *are* 9	2 *are* 10	3 *are* 11	4 *are* 12	5 *are* 13	6 *are* 14	7 *are* 15	8 *are* 16	9 *are* 17
9 *and*	1 *are* 10	2 *are* 11	3 *are* 12	4 *are* 13	5 *are* 14	6 *are* 15	7 *are* 16	8 *are* 17	9 *are* 18
10 *and*	1 *are* 11	2 *are* 12	3 *are* 13	4 *are* 14	5 *are* 15	6 *are* 16	7 *are* 17	8 *are* 18	9 *are* 19
11 *and*	1 *are* 12	2 *are* 13	3 *are* 14	4 *are* 15	5 *are* 16	6 *are* 17	7 *are* 18	8 *are* 19	9 *are* 20
12 *and*	1 *are* 13	2 *are* 14	3 *are* 15	4 *are* 16	5 *are* 17	6 *are* 18	7 *are* 19	8 *are* 20	9 *are* 21

Sign of Addition.

§ **24.** The *sign* +, called *plus*, placed between numbers, signifies that the numbers are to be *added together*.

Thus 5+4, 5 *plus* 4, signifies 5 and 4 added together.

What is the sum of 4+3+2? Of 6+4+8? Of 7+3+4+6?

Sum of Concrete Numbers.

§ **25.** The sum of similar concrete numbers, is a concrete number of the *same kind*.

Thus, the sum of 5 *cents* and 4 *cents* is 9 *cents*.

What is the sum of 6 pounds + 5 pounds? Of 7 days + 3 days + 5 days? Of 10 miles + 9 miles? Of 12 pints + 6 pints + 2 pints?

§ **26.** *Dissimilar* concrete numbers cannot be united in one number.

Thus we cannot add 5 *cents* and 3 *days* together.

RULE III.

§ **27.** *To Add two or more Numbers together.*

1. Set the numbers one under another, with *units* under *units*, tens under tens, &c.

2. Proceeding from *right* to *left*, add up each column of figures, and under each set its amount, if *less than* 10.

3. If the amount be 10 or more, set down its *right hand figure*, and add the left figure or figures to the next column.

Set down the whole amount of the last column.

EXAMPLE.

To find the Sum of 930+6754+8621

$$\begin{array}{r} 930 \\ 6754 \\ \underline{8621} \\ 16305 \end{array}$$

Having set *units* under *units*, tens under tens, &c., we say 1 and 4 are 5, and set 5 under the units' column.

Then, 2 and 5 are 7, and 3 are 10. We set the 0 under the tens' column, and add or *carry* the 1 to the next column; thus 1 and 6 are 7, and 7 are 14, and 9 are 23. We set 3 under that column, and say 2 and 8 are 10, and 6 are 16.

☞The *left hand figure* in the amount of any column, denotes the number of *tens* in that amount; and these *tens* are so many *units* when carried to the next column on the left. (§ 11.)

In the preceding example, the amount of the *tens'* column is 10 *tens.* But 10 *tens* being 1 *hundred,* we set down *no tens,* and add 1 to the hundreds' column,—which makes 23 *hundreds,* or 2 *thousands* and 3 *hundreds.* The 3 is put in the hundreds' place, and the 2 is added to the thousands' column, making 16 thousands.

By thus carrying *one* for every *ten,* from right to left, we find the number belonging to each distinct order of units in the sum of the several numbers. The whole is equal to the sum of all its parts.☜

The Operation Proved.

§ 28. Addition may be *verified* or *proved,* by adding the several columns of figures *downwards;* the Sum must be the same as when they are added upwards.

Thus to prove the operation in the preceding example, we begin at the top, and say 4 and 1 are 5; then 3 and 5 are 8, and 2 are 10. Setting down the 0, and carrying the 1, we say 1 and 9 are 10, and 7 are 17, and 6 are 23; then 2 and 6 are 8, and 8 are 16.

The Sum found is the same as before.

EXERCISES.

1. John has 95 chestnuts, Thomas has 180, and Charles 270; what number have they all together?

The whole number of chestnuts will be found by adding together 95, 180, and 270. *Answer,* 545 chestnuts.

2. A farmer being asked how many sheep he had, replied: "in one field I have 410, in another 500, in another 602." How many had he? *Ans.* 1512 sheep.

3. A merchant bought cloth for 375 dollars, linen for 83 dollars, silk for 234 dollars, and calico for 75 dollars. What sum did he expend for the whole? *Ans.* 767 dollars.

4. A gentleman bought a carriage for 350 dollars, a pair of horses for 240 dollars, and a set of harness for 100 dollars. What did the whole amount to? *Ans.* 690 dollars.

5. Going out to collect money, I received from one person 13 dollars, from another 124 dollars, from another 89 dollars, and from another 20 dollars. What was the whole sum collected? *Ans.* 246 dollars.

6. Suppose a man should raise on the several fields of his farm the following quantities of grain, viz: 685 bushels, 97 bushels, 330 bushels, and 1000 bushels,—how many bushels would he raise altogether? *Ans.* 2112 bushels.

7. Allowing a person's estate to be estimated as follows, viz: real estate 9000 dollars, personal property 1375 dollars, recoverable debts 875 dollars, and cash 300 dollars,—what would be the value of his estate? *Ans.* 11550 dollars.

8. Admitting I bought of A 500 bushels of wheat, of B 934 bushels, of C 83 bushels, and of D 125 bushels,—how many bushels did I buy in all? *Ans.* 1642 bushels.

9. Three persons deposite flour in the same warehouse; the first, 43 barrels; the second 150 barrels; and the third, 89 barrels. What quantity do they all deposite? *Ans.* 282 barrels.

10. A merchant bought four pieces of cloth; the first for 225 dollars, the second for 310 dollars, the third for 279 dollars, and the fourth for 95 dollars. What did the whole cost him? *Ans.* 909 dollars.

11. If a merchant buy a stock of goods for 5000 dollars, for what sum must he sell the goods so as to gain by them 475 dollars? *Ans.* 5475 dollars.

12. Bought a barrel of sugar for 15 dollars, a barrel of molasses for 13 dollars, and a sack of coffee for 20 dollars. For what sum must the whole be sold to gain 10 dollars? *Ans.* 58 dollars.

13. A person on a journey travels, the first week 255 miles; the second, 240 miles; the third and fourth, each 200 miles. How far did he travel in the four weeks? *Ans.* 895 miles.

14. Four persons, A, B, C, and D, engage in speculation. A gains 75 dollars, B 100 dollars, and C and D each 235 dollars; what sum was gained by all together? *Ans.* 645 dollars.

15. A farmer bought three plantations for 3750 dollars each, and sold them again so as to make 1000 dollars on the whole. For what sum did he sell the three. *Ans.* 12250 dollars.

16. A draper sold four bales of linen; the first and second contained each 480 yards; the third and fourth each 542 yards. How many yards did he sell? *Ans.* 2044 yards.

17. Bought of A 325 bushels of wheat; of B, 280 bushels; of C as much as from A; and of D as much as from B. What quantity of wheat did I buy in all? *Ans.* 1210 bushels.

18. A merchant bought at one time 375 barrels of flour, for 1875 dollars; and at another 400 barrels for 2000 dollars. What quantity of flour did the merchant buy, and for what sum? *Ans.* 775 barrels, for 3875 dollars.

19. Find the Sum 345+480+2346+7864. *Ans.* 11035.
20. Find the Sum 201+342+4000+1009. *Ans.* 5552.
21. Find the Sum 804+4364+25+1231. *Ans.* 6424.
22. Find the Sum 58603+75+49+2400. *Ans.* 61127.
23. Find the Sum 73846+37+63+9000. *Ans.* 82946.
24. Find the Sum 7+43+479+8+3703. *Ans.* 4240.
25. Find the Sum 9+60+340+4+8264. *Ans.* 8677.
26. Find the Sum 5+50+600+8+8900. *Ans.* 9563.
27. Find the Sum 6+10+100+9+1000. *Ans.* 1125.

28. A lends to B 2500 dollars; to C 3000; and has 5325 dollars left. What sum had A at first? *Ans.* 10825 dollars.

29. A speculator bought stock at one time for 325 dollars; and at another time for 705 dollars. In selling the whole, he realized a gain of 175 dollars; for what sum did he sell?
Ans. 1205 dollars.

30. A gentleman is 15 years older than his wife, and she is 20 years older than their eldest son, who is 29 years of age. Required the gentleman's age, and the age of his wife?
Ans. His age is 64 years; hers 49.

31. A, B, and C form a partnership in trade. A puts in 4250 dollars; B, 2000 dollars; and C as much as A and B together; what is their whole stock in trade? *Ans.* 12500 dollars.

32. Bought at one time 75 yards of cotton, and 100 yards of linsey; at another, 37 yards of cotton, and 87 yards of linsey; and at another, 125 yards of cotton, and 9 yards of linsey. What quantity of each kind did I buy?
Ans. 237 yards of cotton, and 196 of linsey.

33. A merchant bought cloth for 375 dollars, and silk for 95 dollars. In selling, he gained 50 dollars on the cloth, and 45 dollars on the silk; for what sum did he sell the whole?
Ans. 565 dollars.

34. A grocer paid 300 dollars for sugar, 174 dollars for coffee, 85 dollars for rice, and 56 dollars for tobacco. He sold the sugar at a profit of 25 dollars, and the other articles at cost; what did he get for the whole? *Ans.* 640 dollars.

35. A father bequeaths to his only daughter 2500 dollars, and to each of his two sons, 500 dollars more than to his daughter. What sum did each son receive, and what was the amount of the several bequests?
Ans. { Each son, 3000 dollars,
Amount, 8500 dollars.

36. Several persons contributed towards the establishment of a library. A gave 200 dollars, and B 50 dollars more than A; C gave 300 dollars, and D 25 dollars more than C. What was the whole amount contributed? *Ans.* 1075 dollars.

37. The produce of two farms was as follows, viz: of the first, 785 bushels of wheat, and 250 of rye; of the second, 1000 bushels of wheat, and 113 of rye. What was the entire produce of the farms (§ 26)?

Ans. 1785 bushels of wheat, and 363 of rye.

38. A merchant bought 4 bales of cotton; the first and second contained 470 yards each; and the third and fourth, 532 yards each. What was the number of yards purchased?

Ans. 2004 yards.

39. Bought live stock as follows, viz: of A 13 cows, 16 oxen, and 120 sheep; of B 24 cows, 30 oxen, and 153 sheep: and of C 100 cows, and 425 sheep. It is required to find the amount of stock purchased (§ 26).

Ans. 137 cows; 46 oxen; 698 sheep.

40. A has 2375 dollars; B 150 dollars more than A; and C as much as A and B together. What sum is possessed by C, and what by the three together?

Ans. { C has 4900 dollars.
The three 9800 dollars.

41. A farmer has in store at one place 500 bushels of wheat, 325 of oats, and 50 of corn; and at another, 475 bushels of wheat, 75 of oats, and 83 of corn. What amount of produce has the farmer in store?

Ans. 975 bushels of wheat; 400 of oats; 133 of corn.

42. Bought a quantity of cloth for 386 dollars, of cotton for 200 dollars, and of silk for 150 dollars. The cloth was sold at a profit of 73 dollars, the cotton at a profit of 35 dollars, and the silk at cost. What was the whole sold for?

Ans. 844 dollars.

43. The population of each of the grand divisions of the Earth, is estimated as follows, viz: of Europe, at 238 millions, 473 thousand, nine hundred and fifty-seven; of Asia, at 390 millions; of Africa, at 65 millions; of North America, at 35 millions; of South America, at 15 millions, 240 thousand; and of Oceanica, at 20 millions. What then is the whole population of the several grand divisions of the Earth?

Ans. 763713957 inhabitants.

SUBTRACTION.

§ **29.** SUBTRACTION consists in finding the *difference* between two numbers; that is, the *remainder* when the less number is taken from the greater.

The less number is called the *subtrahend*, and the greater the *minuend*.

Thus 4 from 9 leaves 5; then 4 is the *subtrahend*, 9 the *minuend*, and 5 the *difference* or remainder.

What is the difference between 5 and 8? Between 6 and 10? Between 9 and 15? Between 8 and 17? Between 10 and 19?

Addition and Subtraction.

§ **30.** Addition and Subtraction are the *reverse of each other*.

In Addition, the *parts* are given, to find the *sum* or *whole;* in Subtraction, the *sum* or whole, and one of its parts, are given, to find the *other part*.

The sum being 10, and one of its parts 7, what is the other part? The sum being 13, and one part 6, what is the other part? The sum being 19, and one part 12, what is the other part?

Sign of Subtraction.

§ **31.** The *sign* —, called *minus*, placed between two numbers, signifies that the one before which it stands, is to be *subtracted from the other*.

Thus 9—4, 9 *minus* 4, signifies 4 subtracted from 9.

How many is 8—5? 13—7? 15—4? 18—11? 20—10?
How many is 10—3? 14—9? 17—8? 21—10? 25—15?

Difference of Concrete Numbers.

§ **32.** The difference of two similar concrete numbers, is a concrete number of the *same kind*.

Thus the difference of 5 *cents* and 8 *cents* is 3 *cents*.

What is the difference between 12 pounds and 3 pounds? Between 18 days and 9 days? Between 20 dollars and 12 dollars?

§ **33.** Two *dissimilar* concrete numbers cannot be subtracted, the one from the other.

Thus we cannot subtract 5 *pounds* from 8 *days*.

Constant Difference.

§ 34. The Difference of two numbers remains *the same,* when those numbers are *equally increased* or *diminished.*

What is the difference between 4 and 7? Between 4+1 and 7+1? Between 5 and 9? Between 5+2 and 9+2? Between 7 and 12? Between 7+10 and 12+10? Between 20—9 and 15—9?

RULE IV.

§ 35. *To Subtract one Number from another.*

1. Set the less number under the greater, with *units* under *units,* tens under tens, &c.

2. Proceeding from *right to left,* take each lower figure from the one above it, and underneath set the remainder.

3. If the lower figure *exceed the upper,* add 10 to the upper figure; from the *sum* subtract the lower, and then add 1 to the next lower figure before subtracting it.

EXAMPLE.

To find the Difference between 654739 and 80657.

$$\begin{array}{r}654739\\80657\\\hline 574082\end{array}$$

Having set the less number under the greater, with units under units, tens under tens, &c., and drawn a line below them,

We begin at the right, and say 7 from 9 leaves two; the 5 being greater than the 3 above it, we say 10 and 3 are 13, and 5 from 13 leaves 8; then adding 1 to the 6, making 7, we say 7 from 7 leaves 0; 0 from 4 leaves 4; 10 and 5 are 15, and 8 from 15 leaves 7; there being no figure under the 6, the 1 to be added there makes 1 for that place,—then 1 from 6 leaves 5. The Difference required is 574082.

☞ The 10 added to any upper figure is always equal to the 1 added to the next lower figure (§ 11); so that these additions preserve *the same difference* between the two given numbers (§ 34).

In the preceding example, the 10 *tens* added to the 3 *tens,* are equal to the 1 *hundred* added to the 6 *hundreds;* in like manner the 10 added to the 5 in the upper number is equal to the 1 added to the lower number, and subtracted from the 6.

The several figures in the *remainder* express the differences between the corresponding units, in their several orders, in the two given numbers, or those numbers equally increased in the process of subtracting. ☜

The Operation Proved.

§ 36. Subtraction may be *verified* or *proved*, by adding the *difference* to the less number; the sum must be equal to the greater number.

EXERCISES.

1. William had 325 chestnuts, but gave James 148 of them. How many chestnuts had William left?

The number left is the difference between 325 and 148.

Ans. 177 chestnuts.

2. A person who undertook a journey of 735 miles, has traveled 93 miles of the distance. What distance has he yet to travel? *Ans.* 642 miles.

3. From a farm which contained 2350 acres, 1234 acres were sold. How many acres remained of the original farm?

Ans. 1116 acres.

4. A young man received from his father 5325 dollars, of which he paid 2500 dollars for a house. How many dollars of the first sum had he remaining? *Ans.* 2825 dollars.

5. A merchant deposited 5800 dollars in bank, but afterwards made a draft upon it for 3270 dollars. What sum remained?

Ans. 2530 dollars.

6. Suppose a farmer who has 4000 bushels of wheat in his granary, should take out 2100 bushels to be sent to market; how many bushels would remain? *Ans.* 1900 bushels.

7. A vintner bought 4036 gallons of wine, and afterwards sold at different times to the amount of 2373 gallons. How many gallons had he remaining? *Ans.* 1663 gallons.

8. Suppose I should borrow of my neighbor 1000 dollars, and three months afterwards should pay him 385 dollars of the debt; what balance would still be owing? *Ans.* 615 dollars.

9. A drover bought cattle for 1495 dollars, and sold the same at a loss of 270 dollars. For what sum did he sell them?

Ans. 1225 dollars.

10. A gentleman sold a farm for 6700 dollars, which sum was 530 dollars more than he gave for it. What did he pay for the farm? *Ans.* 6170 dollars.

11. A weaver made 30 pieces of cotton, containing 1200 yards; of which he has sold 17 pieces, containing 875 yards. How many pieces, and how many yards remain?

Ans. 13 pieces; and 325 yards.

12. Bought of A 385 barrels of flour, and 2805 bushels of corn; of which I sold to B 109 barrels of flour, and 936 bushels of corn. What quantity of each remains unsold?

Ans. 276 barrels of flour; 1869 bushels of corn.

13. A salter bought 35850 pounds of beef, and 150000 pounds of pork. Having exported 20500 pounds of the beef, and 75900 pounds of the pork, what quantity of each has he still on hand? *Ans.* 15350 pounds of beef; 74100 of pork.

14. A farmer raised 1200 bushels of wheat, and 213 bushels of oats. He sold to A 835 bushels of wheat, and 179 of oats, and the remainder of the crop to B. What amount of produce did the farmer sell to B?

Ans. 365 bushels of wheat; and 34 of oats.

15. A merchant bought 375 yards of cloth, for 1645 dollars; of which he has sold 103 yards, for 685 dollars. How many yards of the cloth remain on hand, and for what sum must the remainder be sold, to lose nothing?

Ans. 272 yards; and 960 dollars.

16. A grocer bought coffee for 420 dollars, and sugar for 545 dollars. He sold the coffee for 500 dollars, and the sugar for 603 dollars; what did he gain on each?

Ans. 80 dollars on the coffee; and 58 on the sugar.

17. Sold a lot of hams for 275 dollars—which made a profit of 43 dollars; and a lot of cheese for 305 dollars—which made a profit of 39 dollars. What did each kind cost me?

Ans. The hams, 232 dollars; the cheese, 266 dollars.

18. Four persons contribute towards the founding of a literary institution; A gave 2500 dollars, B 3300, C 375 less than A, and D 283 less than B. What were the sums contributed by C and D respectively?

Ans. 2125 dollars by C; and 3017 by D.

19. Find the Difference 230469—85340. *Ans.* 145129.
20. Find the Difference 349130—94131. *Ans.* 254999.
21. Find the Difference 400500—80973. *Ans.* 319527.
22. Find the Difference 739745—76378. *Ans.* 663367.
23. Find the Difference 511839—84674. *Ans.* 427165.
24. Find the Difference 601813—13834. *Ans.* 587979.
25. Find the Difference 803460—45009. *Ans.* 758451.
26. Find the Difference 910311—87300. *Ans.* 823011.
27. Find the Difference 999830—99001. *Ans.* 900829.

28. A borrowed of B 8794 dollars; of which he paid to B at one time 2340 dollars, and at another time 1375 dollars. What balance remains to be paid?

From the whole debt subtract the first payment, and from the remainder subtract the second payment. *Ans.* 5079 dollars.

29. A person who set out on a journey of 900 miles, traveled the first week 255 miles, and the second 233 miles. How many miles then remained to be traveled? *Ans.* 412 miles.

30. A testator provided in his will, that his estate, valued at 25479 dollars, should be divided as follows, viz: his only son to have 13500 dollars, his only daughter 5375 dollars, and his widow the remainder. What sum did the widow receive ?
Ans. 6604 dollars.

31. A gentleman who owned a tract of land containing 15735 acres, sold from it, at different times, 3050 acres, 521 acres, 200 acres, and 2370 acres. How many acres of the tract had he then remaining ? *Ans.* 9594 acres.

32. Borrowed of my neighbor at one time 175 dollars, at another 340 dollars, and at another 520 dollars. Having paid him 685 dollars, what balance have I yet to pay ?

From the sum 175+340+520, *subtract* 685.

Ans. 350 dollars.

33. Put in store at one time 500 pounds of hemp; at another time 3800 pounds; and at another 2005 pounds. Having withdrawn 3473 pounds, what quantity remains in store ?
Ans. 2832 pounds.

34. A merchant bought flour at one time for 325 dollars; and at another time for 460 dollars. Having become damaged, the whole was sold at a loss of 184 dollars; for what sum was it sold ? *Ans.* 601 dollars.

35. A grocer purchased brandy for 195 dollars, and wine for 370 dollars. He sold the former at a loss of 35 dollars, and the latter at a loss of 80 dollars. What did he get for the whole ? *Ans.* 450 dollars.

36. A manufacturer sold two bales of cotton, which together contained 2000 yards. The first bale containing 985 yards, how many yards were in the second bale? *Ans.* 1015 yards.

37. A bought of B 875 acres of land, for 23400 dollars. For 500 acres of the tract, he paid 11379 dollars; how many acres were in the remainder of the tract, and for what sum was it purchased ? *Ans.* 375 acres; and 12021 dollars.

38. One farmer had two fields of corn, each producing 230 barrels; and another had three fields, each producing 195 barrels. Which of the two raised the larger crop, and by how many barrels ? *Ans.* The second, by 125 barrels.

39. Three persons, A, B, and C, propose to purchase a manufactory, valued at 25850 dollars. A agrees to pay 5000 dollars, B twice as much as A, and C the remainder; what sum will C have to pay ? *Ans.* 10850 dollars.

40. A merchant exchanges a stock of goods worth 6725 dollars, and a house worth 3120 dollars, with a farmer, for a tract of land valued at 5900 dollars,—the deficiency on the part of the land to be made up in money. What sum will the merchant receive ? Ans. 3945 dollars.

41. A has 2070 dollars more than B, and 375 dollars less than C, who has 4000 dollars; what sum then has B ?

Ans. 1555 dollars.

42. Two travelers start together from the same place, and journey in the same direction, for three successive weeks,—the first at the rate of 240, the second 275 miles, per week; how far are the travelers apart at the end of the time named ?

Ans. 105 miles.

43. Having 4800 dollars on hand, I wish to add to this a sum which will enable me to purchase a farm at 5390 dollars, and leave 300 dollars for other purposes. Required the sum to be added to the first one. *Ans.* 890 dollars.

44. A planter sold cotton amounting to 3460 dollars, and out of these proceeds purchased groceries for 150 dollars, and other provisions for 375 dollars. How much of the first sum had he remaining ? *Ans.* 2935 dollars.

45. A cabinet maker sold furniture to the amount of 4000 dollars, and received, in part payment, at different times, 100 dollars, 200 dollars, 475 dollars and 904 dollars. How much of the debt remains to be paid ? *Ans.* 2321 dollars.

46. A says to B, "in my fruitful pastures, I have 300 fat oxen." B replies, "then I have 120 more than you." Says C, "I lack but 35 of having as many as you both." How many had C ? *Ans.* 685 oxen.

47. In 1820, the population of the United States was 9 millions, 638 thousand, one hundred and sixty-three; in 1830, it was 12 millions, 856 thousand, one hundred and sixty-five; and in 1840, 17 millions, 63 thousand, three hundred and fifty-three. What was the increase from 1820 to 1830, and what from 1830 to 1840 ?

Ans. { 3218002, from 1820 to 1830;
4207188, from 1830 to 1840.

48. The population of Europe being estimated at 238 millions, 473 thousands, 957; of Asia at 390 millions; of Africa at 65 millions; of Oceanica at 20 millions; of N. America at 35 millions; and of S. America at 15 millions, 240 thousand;—how much does the population of Asia exceed that of all the other grand divisions of the Earth ?

Ans. 16286043 inhabitants.

MULTIPLICATION.

§ **37.** Multiplication consists in finding the sum or *product* of a number *taken any given number of times.*

The number *multiplied* is called the *multiplicand;* and the multiplying number, the *multiplier;* the two together are also called the *factors* of the product.

Thus, 3 *times* 5 is 15; then 3 is the *multiplier,* 5 the *multiplicand,* and 15 the *product.* Also 3 and 5 are the *factors* of 15.

How many is 3 times 2? Which is the multiplicand? The multiplier? The product? The *factors?*
How many is 3 times 3? 4 times 3? 5 times 3? 6 times 3?

Addition and Multiplication.

§ **38.** The addition of the *same number to itself,* repeatedly, is a *multiplication* of that number.

Thus 5+5+5 is 3 *times* 5; the *sum* or *product* being 15.

How many is 6+6, or *twice* 6?	6+6+6, or 3 times 6?
How many is 7+7, or twice 7?	7+7+7, or 3 times 7?
How many is 8+8+8, or 3 times 8?	8+8+8+8, or 4 times 8?
How many is 9+9+9, or 3 times 9?	9+9+9+9, or 4 times 9?

Recite the *elementary products, once* 1 is 1, *once* 2 is 2, &c., *twice* 1 is 2, *twice* 2 is 4, &c., 3 *times* 1 is 3, 3 *times* 2 is 6 &c., as given from left to right in the

Multiplication Table.

Once	1	2	3	4	5	6	7	8	9	10	11	12
Twice	*is* 2	*is* 4	*is* 6	*is* 8	*is* 10	*is* 12	*is* 14	*is* 16	*is* 18	*is* 20	*is* 22	*is* 24
3 *times*	*is* 3	*is* 6	*is* 9	*is* 12	*is* 15	*is* 18	*is* 21	*is* 24	*is* 27	*is* 30	*is* 33	*is* 36
4 *times*	*is* 4	*is* 8	*is* 12	*is* 16	*is* 20	*is* 24	*is* 28	*is* 32	*is* 36	*is* 40	*is* 44	*is* 48
5 *times*	*is* 5	*is* 10	*is* 15	*is* 20	*is* 25	*is* 30	*is* 35	*is* 40	*is* 45	*is* 50	*is* 55	*is* 60
6 *times*	*is* 6	*is* 12	*is* 18	*is* 24	*is* 30	*is* 36	*is* 42	*is* 48	*is* 54	*is* 60	*is* 66	*is* 72
7 *times*	*is* 7	*is* 14	*is* 21	*is* 28	*is* 35	*is* 42	*is* 49	*is* 56	*is* 63	*is* 70	*is* 77	*is* 84
8 *times*	*is* 8	*is* 16	*is* 24	*is* 32	*is* 40	*is* 48	*is* 56	*is* 64	*is* 72	*is* 80	*is* 88	*is* 96
9 *times*	*is* 9	*is* 18	*is* 27	*is* 36	*is* 45	*is* 54	*is* 63	*is* 72	*is* 81	*is* 90	*is* 99	*is* 108
10 *times*	*is* 10	*is* 20	*is* 30	*is* 40	*is* 50	*is* 60	*is* 70	*is* 80	*is* 90	*is* 100	*is* 110	*is* 120
11 *times*	*is* 11	*is* 22	*is* 33	*is* 44	*is* 55	*is* 66	*is* 77	*is* 88	*is* 99	*is* 110	*is* 121	*is* 132
12 *times*	*is* 12	*is* 24	*is* 36	*is* 48	*is* 60	*is* 72	*is* 84	*is* 96	*is* 108	*is* 120	*is* 132	*is* 144

Constant Product.

§ **39.** The Product of two numbers remains *the same*, when the multiplicand and multiplier are taken *the one for the other.*

Thus 3 *times* 15 gives the *same product* as 15 *times* 3.

For, 3 times 15 must be 15 times as many as 3 times 1, which is 3; that is, 3 times 15 is just as many as 15 times 3.

Prove that 4 times 23 is equal to 23 times 4. Prove that 5 times 17 is equal to 17 times 5. Prove that 6 times 39 is equal to 39 times 6.

Sign of Multiplication.

§ **40.** The *sign* ×, called *into*, placed between two numbers, signifies that they are to be *multiplied together.*

Thus 9×4, 9 *into* 4, signifies 9 *times* 4, or 4 *times* 9.

How many is 6×7? 5×9? 8×3? 4×11? 8×9? 3×7?
How many is 9×9? 7×8? 8×6? 4×12? 9×6? 8×4?
How many is 3×7? 5×8? 3×9? 5×10? 6×7? 2×11?
How many is 8×7? 6×5? 7×6? 6×11? 4×7? 3×12?

Product of Concrete Numbers.

§ **41.** The product of a concrete number taken any number of times, is a *similar* concrete number.

Thus 3 times 5 *cents* is 15 *cents.*

What is 3 times 9 pounds? 4 times 7 yards? 3 times 8 dollars? 6 times 9 miles? 7 times 10 acres? 8 times 11 furlongs?

§ **42.** A concrete number cannot be taken *concretely* as a *multiplier;* for, as a multiplier, a number can express nothing but *repetitions* of the multiplicand.

For example, 3 *hats* at 5 dollars apiece would amount to 3 times 5 dollars, which is 15 dollars; the multiplier 3 expressing only *repetitions* of 5 dollars. We multiply by 3,—not by 3 *hats.*

What would 4 slates amount to at 10 cents apiece? What would 5 books amount to at 8 cents apiece? What would 6 pounds of butter amount to at 12 cents a pound? What would 7 cords of wood amount to at 3 dollars a cord? What would 8 pair of boots amount to at 5 dollars a pair? What would 9 tons of hay amount to at 8 dollars a ton?

If a man can walk 4 miles an hour, how far could he walk in 10 hours? If a yard of cloth sells for 6 dollars, what should be paid for 11 yards at the same rate? Allowing 12 men to do a piece of work in 5 days, in what time ought one man to do the same?

RULE V.

§ **43.** *To Multiply by a Number not exceeding* 12; *or by such Number with* 0s *annexed.*

1. Proceeding from *right to left,* multiply each figure of the multiplicand, and under each set its product, when *less than* 10.

2. When the product is 10 or more, set down its *right hand figure,* and add the left figure or figures to the next product. Set down the whole of the last product.

3. *Ciphers in the right of either or both of the factors,* are omitted in multiplying; but as many 0s must be placed in the *right of the product.*

4. When the multiplier is 10, or 100, &c., the product will be formed by merely *annexing to the multiplicand* as many 0s as there are 0s in the right of the Multiplier.

EXAMPLES.

1. To Multiply 5070 by 3; that is, to find 3 *times* 5070.

$$\begin{array}{r} 5070 \\ 3 \\ \hline 15210 \end{array}$$

We place a 0 in the right of the product, for the 0 in the right of the multiplicand; and then say,

3 times 7 is 21; setting down the 1, we say 3 times 0 is 0, and the 2, from 21, added, makes 2; 3 times 5 is 15.

The required product is 15210.

2. To Multiply 243 by 30; or to find 30 *times* 243.

$$\begin{array}{r} 243 \\ 30 \\ \hline 7290 \end{array}$$

Having placed a 0 in the right of the product, for the 0 in the right of the multiplier, we say

3 times 3 is 9; 3 times 4 is 12; 3 times 2 is 6, and 1 makes 7.

3. To multiply 359 by 100, we merely *annex two* 0s to the multiplicand, and thus find the *product* 35900.

☞ The adding of the *left hand figure* in the product of any figure, to the next product, is carrying *one* for every *ten*, as in Addition.

In the first example, we might have begun by saying 3 times 0 is 0, and then said 3 times 7 is 21, &c. But this amounts to the same thing as merely placing a 0 on the right, and beginning the multiplication with 3 times 7.

In the second example, 243 multiplied by 3 produces 729. But since the true multiplier is 30, which is 10 times 3, the true product must be 10 times 729; and this *tenfold* value is assigned to 729 by the 0 on the right, which removes each of its figures one place farther toward the left from units (§ 16).

We thus find that for each 0 omitted in the right of either factor, a 0 must be placed in the right of the product. ☜

The Operation Proved.

§ **44.** Multiplication may be *verified* or *proved*, by multiplying the multiplicand by the multiplier *minus* 1, and adding the multiplicand to the product thus obtained; the sum must be equal to the product found with the *entire multiplier*.

EXERCISES.

1. Mary bought two books, at 31 cents apiece. How many cents did she pay for them?

The 2 books cost twice 31 *cents;* or 31 *cents*+31 *cents* (§ 38).
Ans. 62 cents.

2. A farmer sold 3 horses at 125 dollars apiece. What sum did he receive for them? *Ans.* 375 dollars.

3. What would be the value of 20 shares of road stock, at 95 dollars for each share? *Ans.* 1900 dollars.

4. What would be the weight of 30 bales of cotton, allowing 450 pounds to each bale? *Ans.* 13500 pounds.

5. How many pounds of flour are there in 10 barrels of flour, there being 196 pounds in each barrel? *Ans.* 1960 pounds.

6. If a steamboat can run 305 miles in a day, how many miles could it run in 4 days? *Ans.* 1220 miles.

7. There being 1760 yards in a mile, what number of yards is there in 5 miles? *Ans.* 8800 yards.

8. A farmer sold 100 acres of land, at 43 dollars per acre. What sum did he receive for the land? *Ans.* 4300 dollars.

9. There being 660 feet in a furlong, how many feet are there in a mile, which is 8 furlongs? *Ans.* 5280 feet.

10. A merchant bought 60 sacks of coffee, at 13 dollars a sack. What did the whole amount to? *Ans.* 780 dollars.

11. A butcher bought 7 fat oxen, at an average of 32 dollars a head. What sum did he pay for them? *Ans.* 224 dollars.

12. Find the sum that should be paid for 9 horses at 130 dollars apiece, and 10 cows at 21 dollars apiece.
Ans. 1380 dollars.

13. Bought at one time 5 coils of rope, each containing 139 yards; and at another, 7 coils, each containing 150 yards. What was the whole number of yards bought?
Ans. 1745 yards.

14. A farmer bought 5 horses, at 95 dollars each; 12 mules, at 60 dollars each; and 40 head of cattle, at 27 dollars a head. What did he pay for all the stock purchased?
Ans. 2275 dollars.

15. Sold to A 7 pieces of cotton, to B 11 pieces, and to C 12 pieces,—each piece containing 31 yards. What was the number of pieces, and what the number of yards that was sold?
Ans. 30 pieces; and 930 yards.

16. A merchant bought 213 beaver hats, at 4 dollars apiece. What did the whole amount to?

The hats amounted to 213 *times* 4 *dollars; but* 4 *times* 213 *is the same number as* 213 *times* 4. (§ 39). *Ans.* 852 dollars.

17. Bought 175 cords of wood, at 3 dollars per cord. What did the whole amount to? *Ans.* 525 dollars.

18. A planter sold 325 bales of cotton, at the average sum of 30 dollars per bale. What did the sale amount to?
Ans. 9750 dollars.

19. If a steam ship can run at the rate of 300 miles per day, how far would she run in 31 days. *Ans.* 9300 miles.

20. A drover sold 573 head of cattle, at the average price of 20 dollars a head. What did the sale amount to?
Ans. 11460 dollars.

21. A farmer filled, at one time, 83 sacks of corn; and at another time 112 sacks;—each sack containing 5 bushels. What quantity of corn was put into all the sacks?
Ans. 975 bushels.

22. Bought of A, 137 acres of land; of B, 89 acres; and of C, 384 acres;—at the average price of 40 dollars per acre. What quantity of land was bought, and what sum was paid for it? *Ans.* 610 acres; and 24400 dollars.

23. Shipped to New Orleans, at one time, 120 barrels of apples; at another, 75 barrels; at another, 100 barrels; and at another, 9 barrels;—each barrel containing 3 bushels. Required the number of barrels, and the number of bushels shipped. *Ans.* 304 barrels; and 912 bushels.

24. A merchant bought 275 yards of cloth, at 6 dollars per yard, of which he has sold 133 yards, at 10 dollars per yard. What would he gain on the whole, by selling the remainder at 9 dollars per yard? *Ans.* 958 dollars.

25. If 10 masons can build a wall, in 34 days; in how many days ought one mason to build the same wall?

It would take 1 *mason* 10 *times as long as it would* 10 *masons, to build the wall; that is,* 10 *times* 34 *days.* *Ans.* 340 days.

26. How long ought one man to subsist on a stock of provisions which would support 7 men for 29 days?
Ans. 203 days.

27. If 9 men could mow a certain meadow, in 19 days; in how many days ought one man to mow the meadow?
Ans. 171 days.

28. If 115 bushels of oats will feed one horse for 3 months; what quantity of oats would feed 12 horses, the same time?
Ans. 1380 bushels.

29. Allowing 20 pieces of artillery to demolish a fortress in 48 hours, in what time ought one piece to demolish the fortress?
Ans. 960 hours.

30. A lent B 8 yoke of working oxen, for 13 days. How long ought B to lend A 1 yoke, to requite the favor?
Ans. 104 days.

31. C exchanges silk, at 1 dollar per yard, with D, for broadcloth, at 7 dollars per yard. How many yards of silk should be given for 125 yards of broadcloth? *Ans.* 875 yards.

32. Two merchants barter as follows: A gives 75 yards of cloth, at 9 dollars per yard, to B, for 109 beaver hats, at 7 dollars apiece; the deficiency on either side being made good in money. Which of them receives money, and how much?
Ans. B receives 88 dollars.

33. A gave B 3 horses, and 30 head of cattle, for 50 barrels of flour and 200 barrels of corn. A sold the flour at 6 dollars, and the corn at 3 dollars a barrel; while B sold his horses at 120 dollars, and his cattle at 25 dollars, each? Which of the two gained by the trade, and how much?
Ans. B gained 210 dollars.

34. Find the Product 10×24738730. *Ans.* 247387300.
35. Find the Product 200×3076801. *Ans.* 615360200.
36. Find the Product 1200×706840. *Ans.* 848208000.
37. Find the Product 90×10707800. *Ans.* 963702000.
38. Find the Product 300×7060000. *Ans.* 2118000000.
39. Find the Product 1100×870003. *Ans.* 957003300.
40. Find the Product 12000×70000. *Ans.* 840000000.

RULE VI.

§ **45.** *To Multiply by any Number exceeding* 12, *and containing two or more* SIGNIFICANT FIGURES.

1. Multiply by each *significant figure*, separately, of the multiplier,—placing the several rows of products one under another, with the first figure of each product *under the multiplying figure,*—and, in that order, add the several products together for the *entire product.*

2. *Ciphers in the right of either or both of the factors*, are omitted in multiplying; but as many 0s must be placed in the *right* of the product.

EXAMPLES.

1. To Multiply 8072 by 39; that is, to find 39 *times* 8072.

$$\begin{array}{cccccc}
 & & 8 & 0 & 7 & 2 \\
 & & & & 3 & 9 \\
\hline
 & 7 & 2 & 6 & 4 & 8 \\
2 & 4 & 2 & 1 & 6 & \\
\hline
3 & 1 & 4 & 8 & 0 & 8
\end{array}$$

Multiplying first by 9, we say 9 times 2 is 18, and set the first product figure 8 under the multiplying figure 9; then, 9 times 7 is 63, and 1 makes 64; 9 times 0 is 0, and 6 makes 6, &c.

Multiplying next by 3, we say 3 times 2 is 6, and set the 6 under the multiplying figure 3; 3 times 7 is 21; 3 times 0 is 0, and 2 is 2, &c.

Adding the two rows of product figures together, in the order in which they stand, we say 8 is 8; 6 and 4 are 10, &c.

The entire Product is 314808.

2. To Multiply 8420 by 30900; or to find 30900 *times* 8420;

$$\begin{array}{ccccccccc}
 & & & 8 & 4 & 2 & \vert\, 0 & & \\
 & & & 3 & 0 & 9 & \vert\, 0 & 0 & \\
\hline
 & & 7 & 5 & 7 & 8 & & & \\
2 & 5 & 2 & 6 & & & & & \\
\hline
2 & 6 & 0 & 1 & 7 & 8 & 0 & 0 & 0
\end{array}$$

Omitting 0s in the right of both factors, we multiply 842 by 309, setting the first figures, 8 and 6, of the products under the multiplying figures, 9 and 3, respectively. To the product thus found, we annex three 0s, for the 0s omitted in multiplying.

☞ When the multiplying figure is *tens*, or *hundreds*, &c., the first product figure is set under *tens*, or *hundreds*, &c., respectively, to *increase the product* in the same degree in which the multiplying figure is increased in value, by distance from the unit's place (§ 16).

In the *first* example, 2 multiplied by 3 produces 6. But the 3 is 3 *tens*, or 10 *times* the simple 3; the 6 must therefore be 10 *times* the simple 6; and this *tenfold* value is assigned to 6 by setting it under the 3 *tens*, and *adding it in the ten's column.*

In the *second* example, we multiplied 842 by 309. In 309 the 3 is 3 *hundreds*, or 100 *times* the simple 3. The first product figure 6 must therefore be 100 *times* the simple 6; and this *hundredfold* value is assigned to 6 by setting it under the 3 *hundreds*, and *adding it in the hundreds' column.*

The first product figure being set in its proper place, the second, third, &c., fall in their proper places, in ascending orders of units towards the left.—The sum of the *partial* products is the entire product (§23).

As already shown, in connexion with Rule V, for each 0 omitted in the right of either factor, a 0 must be placed in the right of the product. ☜

EXERCISES.

41. Find the Product 24×360730. *Ans.* 8657520.
42. Find the Product 307×80379. *Ans.* 24676353.
43. Find the Product 5372×7684. *Ans.* 41278448.
44. Find the Product 80760×870. *Ans.* 70261200.
45. Find the Product 13×730000. *Ans.* 9490000.
46. Find the Product 740×87305. *Ans.* 64605700.
47. Find the Product 9034×8076. *Ans.* 72958584.
48. Find the Product 30407×307. *Ans.* 9334949.
49. Find the Product 400070×990. *Ans.* 396069300.

50. The number of yards in a mile being 1760, how many yards are there in 15 miles?

The number of yards in 15 *miles is* 15 *times* 1760 *yards.*

Ans. 26400 yards.

51. There are 24 hours in one day. How many hours then are there in a year of 365 days?

The number of hours in a year is 365 *times* 24 *hours;* but 24 times 365 will produce the same number, and it is more convenient to make the *less* number the *multiplier.*

Ans. 8760 hours.

52. A hogshead of wine or brandy contains 63 gallons. How many gallons would there be in 250 hogsheads?

Ans. 15750 gallons.

53. What sum should be paid for a plantation containing 765 acres, at 43 dollars per acre? *Ans.* 32895 dollars.

54. If a man can walk 35 miles in a day, how far could he walk, at that rate, in a year, or 365 days? *Ans.* 12775 miles.

55. A has 340 acres of land worth 18 dollars an acre; and B has 239 acres worth 22 dollars an acre. How many acres have the two together, and what is the value of the whole.

Ans. 579 acres; and 11378 dollars.

56. A merchant bought 475 barrels of flour, at 15 dollars a barrel. He sold 280 barrels of it, at 16 dollars, and the rest at 14 dollars a barrel; what did he gain or lose?

Ans. gained 85 dollars.

57. One manufacturer exported 234 bales of cotton cloth,—each bale containing 2400 yards; another exported 370 bales, each containing 1050 yards. Which of them exported the greater quantity, and by how many yards?

Ans. The first, 173100 yards.

58. Farmer A had in wheat 205 acres, which produced 27 bushels per acre. Farmer B had 320 acres, which produced 19 bushels per acre. What quantity of wheat was raised by them both. *Ans.* 11615 bushels.

59. A speculator bought 150 head of cattle, and 47 mules. He made a profit of 13 dollars a head on the former, and 17 on the latter; what was gained by the speculation?

Ans. 2749 dollars.

60. Bought 360 acres of land, at 35 dollars per acre; and at another time double that quantity, at double the price per acre. What was the whole quantity of land purchased, and the sum paid for it? *Ans.* 1080 acres; and 63000 dollars.

61. Two persons start together from the same place, and travel in the same direction. One proceeds at the rate of 29 miles per day, and the other at the rate of 31 miles per day. What distance will be between them at the end of 25 days?

Ans. 50 miles.

62. A merchant bought 18 bales of linen, each containing 22 pieces, and each piece containing 40 yards. How many pieces and how many yards did he buy?

Ans. 396 pieces; and 15840 yards.

63. In a certain orchard there are 30 rows of apple trees, with 44 trees in each row. Allowing 2500 apples to each tree, what number of apples would there be in the orchard?

Ans. 3300000 apples.

64. A farmer bought three tracts of land. The first and second contained each 280 acres, and the third as many as both the other two; how many acres did the farmer purchase, and what did the whole amount to, at 33 dollars per acre?

Ans. 1120 acres; and 36960 dollars.

65. Allowing a person's annual income to be 5000 dollars, and his daily expenses 3 dollars, what would be the amount of his annual saving,—there being 365 days in a year?

Ans. 3905 dollars.

66. If 327 head of cattle were purchased at 13 dollars a head, and 405 were purchased at 11 dollars a head, what would be the profit or loss on the whole at 12 dollars a head?

Ans. Profit, 78 dollars.

67. A planter sold 139 bales of cotton, at an average of 32 dollars per bale, and out of the proceeds bought 29 mules, at 49 dollars each, and 4 pair of oxen, at 52 dollars a pair; what sum had he left from the sale of his cotton?

Ans. 2819 dollars.

68. A sends 209 tons of coal to New York city; B sends as much as A, wanting 10 tons; and C sends as much as A and B together. What was each man's proceeds of sale, at 13 dollars per ton? *Ans.* A's 2717 dollars; B's 2587; C's 5304.

69. The President of the United States receives a salary of 25 thousand dollars a year. To what sum does his salary amount in 4 years, or one presidential term?

Ans. 100000 dollars.

70. The circumference of the Earth is about 25 thousand miles, and the distance to the Sun is 3 thousand 8 hundred times the Earth's circumference. What then is the distance to the Sun? *Ans.* 95000000 miles.

71. The velocity of light is 192 thousand 500 miles per second. Through what distance then does light move in one minute, which is 60 seconds? *Ans.* 11550000 miles.

72. The Earth turns around its axis once in every 24 hours, and moves 68 thousand miles an hour in its orbit around the Sun. How far then are we carried along the Earth's orbit during one revolution of the Earth on its axis?

Ans. 1632000 miles.

DIVISION.

§ **46.** Division consists in finding *how many times* a greater number *contains* a less, or *what part* a less number is of a greater.

The number to be divided is called the *dividend;* the dividing number the *divisor;* and the *number* or *part* found, the *quotient.*

One *half* is one of the *two equal parts,*—two *thirds* are two of the *three equal parts,*—and so on, into which any quantity may be divided.

What is meant by one *third?* By one *fourth?* By three *fourths?* By one *fifth?* By two *fifths?* By one *tenth?* By five *ninths?*

When we say 2 is contained in 6, 3 times, we divide 6 by 2; 6 is the *dividend,* 2 the *divisor,* and 3 the *quotient.*

Also, 2 is *one third* of 6, because if 6 were divided into *three equal parts,* each part would be 2.

How many times is 3 contained in 6? 3 is what part of 6?
How many times is 4 contained in 12? 4 is what part of 12?
How many times is 5 contained in 20? 5 is what part of 20?
If the dividend be 24, and the divisor 4, what will the *quotient* be? If the dividend be 35, and the divisor 5? If the dividend be 42, and the divisor 7? If the dividend be 56, and the divisor 8?

§ **47.** The Quotient of a *less number* divided by a greater, is the *part that the less is* of the greater; and is denoted by the less over the greater, with a line between them.

Thus 1 divided by 2 is $\frac{1}{2}$ *one half,* because 1 is *one half* of 2.

How much is 1 divided by 3; that is, 1 is what part of 3?
How much is 1 divided by 4? 1 divided by 5? 1 divided by 6?
How much is 2 divided by 3; that is, 2 is what part of 3?
How much is 2 divided by 5? 2 divided by 7? 3 divided by 5?

Subtraction and Division.

§ **48.** The subtraction of a less number from a greater, repeatedly, is equivalent to *dividing the greater* by the less, because it shows how many times the greater *contains the less.*

Thus 5 from 15 leaves 10, 5 from 10 leaves 5, and 5 from 5 leaves 0; so that 5 may be *subtracted* 3 times from 15, or is *contained* 3 times in 15.

How many times may 5 be subtracted from 20? How many times may 6 be subtracted from 24? 7 from 35? 8 from 48?

Multiplication and Division.

§ **49.** Multiplication and Division are the *reverse of each other.*

In Multiplication, two numbers or *factors* are given, to find their product; in Division, a product and one of its factors are given, to find the *other factor.*

The product being 15, and one factor 3, what is the other factor?
The product being 30, and one factor 5, what is the other factor?
The product being 36, and one factor 9, what is the other factor?
The product being 63, and one factor 7, what is the other factor?

Reciprocal of a Number.

§ **50.** The *reciprocal* of a number is a unit or 1 *divided by that number.*

Thus the reciprocal of 2 is $\frac{1}{2}$, and of 3 is $\frac{1}{3}$.

What is the reciprocal of 4? Of 5? Of 6? Of 10? Of 20?

The Quotient as a Part of the Dividend.

§ **51.** The Quotient is always such a part of the dividend as is expressed by the *reciprocal of the divisor.*

Thus 15 divided by 5 gives 3, and 3 is $\frac{1}{5}$ of 15.

Again, if we divide 2 by 3, the quotient will be $\frac{2}{3}$ (§ 47); and since *two thirds* of any quantity is *one third* of *two such quantities*, $\frac{2}{3}$ is equal to $\frac{1}{3}$ of 2; *such a part of the dividend* 2 as is expressed by the *reciprocal* of the divisor 3.

$\frac{3}{4}$ of 1 *cent* is what part of 3 *cents?*	$\frac{3}{4}$ of 1 is what part of 3?
$\frac{2}{5}$ of 1 pint is what part of 2 pints?	$\frac{2}{5}$ of 1 is what part of 2?
$\frac{5}{7}$ of 1 mile is what part of 5 miles?	$\frac{5}{7}$ of 1 is what part of 5?
$\frac{1}{6}$ of 5 cents is what part of 1 cent?	$\frac{1}{6}$ of 5 is what part of 1?
$\frac{1}{8}$ of 7 pints is what part of 1 pint?	$\frac{1}{8}$ of 7 is what part of 1?
$\frac{1}{9}$ of 8 miles is what part of 1 mile?	$\frac{1}{9}$ of 8 is what part of 1?

How would you find $\frac{1}{2}$ of any number? $\frac{1}{3}$ of any number? $\frac{1}{7}$ of any number? $\frac{1}{10}$ of any number? $\frac{1}{25}$ of any number?

Sign of Division

§ **52.** The *sign* ÷, called *by*, placed between two numbers, signifies that the first of them is to be *divided by the second.*

Thus 36÷9, 36 *by* 9, signifies that 36 is to be divided by 9.

How many is 24÷6? 35÷7? 63÷9? 100÷10? 144÷12?
How much is 5÷13? 8÷23? 9÷34? 11÷65? 13÷95?

Division is also denoted by the dividend over the divisor with a line between them.

Thus $\frac{63}{9}$ denotes the same as 63÷9.

Quotient of Concrete Numbers.

§ 53. When the dividend and divisor are *similar* concrete numbers, the quotient is the number of times the dividend *contains the divisor*, or the *part the dividend is* of the divisor.

Thus 12 *cents*÷3 *cents* gives 4; and 12 cents÷13 cents gives $\frac{12}{13}$ (§ 47).

How many times 4 miles in 12 miles? 5 pounds in 30 pounds? 6 inches in 42 inches? 7 yards in 77 yards? 12 dollars in 96 dollars? What part is 3 days of 7 days? What part is 9 ounces of 20 ounces? What part is 20 feet of 49 feet?

§ 54. When the dividend and divisor are *dissimilar* concrete numbers, the quotient is such a *part of the dividend* as is expressed by the reciprocal of the divisor taken *abstractly*.

For example, if 5 *pencils* cost 20 *cents*, one pencil will cost 20 *cents*÷5; that is, $\frac{1}{5}$ of 20 cents, which is 4 cents.

If 3 *slates* cost 36 *cents*, what will one slate cost? If 4 *hats* cost 16 *dollars*, what will one hat cost? If in 9 *hours* a stage runs 54 *miles*, at what rate does it run per hour?

Remainder in Division.

§ 55. A *remainder*, in Division, is an *overplus* or *excess* of *the dividend* above so many times the divisor as it is contained in the dividend.

Thus 5 is contained in 17, 3 times, with 2 *over*, since 3 times 5 is 15; then 2 is the *remainder* of the dividend.

If the divisor be 6, and the dividend 27, what will the *quotient* and the *remainder* be? If the divisor be 8, and the dividend 45? If the divisor be 9, and the dividend 70?

§ 56. The *remainder* divided by the divisor, and so annexed to the quotient, *completes the quotient.*

Thus 17÷5 gives quotient 3, and remainder 2. This 2÷5 gives $\frac{2}{5}$ (§ 47); the *complete quotient* is then $3\frac{2}{5}$, *three* and *two-fifths.*

In like manner find the quotient of 9÷2. Of 13÷4. Of 21÷5. Of 27÷6. Of 30÷7. Of 41÷8. Of 100÷9.

Constant Quotient.

§ 57. The quotient of two numbers remains *the same,* when those numbers are *both multiplied,* or both divided, by the same number.

For example, 6÷2 gives 3, and 5 times 6÷5 times 2, that is, 30÷10, also gives 3. By reversing the process, we find 30÷10 equal to $\frac{1}{5}$ of 30÷$\frac{1}{5}$ of 10.

RULE VII.

§ 58. *To Divide by a number not exceeding* 12; *or by such Number with* 0s *annexed.*

1. Take figures enough in the *left of the dividend* to contain the divisor, and set down the number of times the divisor goes therein, noting the *excess,* if any.

2. Take the next figure of the dividend, with the *preceding excess,* if any, *prefixed,* and set the number of times the divisor is found therein on *the right* of the first quotient; if the divisor *will not go therein,* put a 0 in the quotient, and include the next figure in dividing; and so on.

3. *Ciphers in the right of the divisor* are omitted in dividing; but as many figures must be omitted in the right of the dividend, and *annexed to the remainder.* If there be no other remainder, these figures will form the remainder.

4. When the divisor is 10 or 100, &c., take for the *remainder* as many figures from the right of the dividend as there are 0s in the right of the divisor, and the *other figures* of the dividend for the *quotient.*

5. *Under the remainder,* if any, set the given divisor, and annex the part so found to the quotient.

EXAMPLES.

1. To divide 7805 by 3.

$$\begin{array}{r} 3\overline{)7805} \\ \hline 2601\frac{2}{3} \end{array}$$

We say, 3 in 7, *twice,* and 1 *over;* prefixing the 1 to the next figure 8 of the dividend, we have 18; 3 in 18, 6 times; 3 in 0, 0 time; 3 in 5, *once,* and 2 over. This excess 2 is the remainder,—under which setting the divisor 3, we have $\frac{2}{3}$ to annex to the quotient (§ 56).

The quotient $2601\frac{2}{3}$ shows that the dividend 7805 contains the divisor 3, 2601 times, and $\frac{2}{3}$ of the divisor, besides.

The quotient is also $\frac{1}{3}$ of 7805 (§ 51.)

2. To divide 13127 by 120.

$$\begin{array}{r} 12|0)\underline{1\,3\,1\,2|7} \\ 1\,0\,9\,\tfrac{47}{120} \end{array}$$

Omitting the 0 in the right of the divisor, and the 7 in the right of the dividend, we say,

12 in 13 *once*, and 1 over; prefixing the 1 over to the next *figure* of the dividend, we say 12 in 11, 0 time; including the next *figure* 2 of the dividend, we say 12 in 112, 9 times, and 4 over.

Annexing the 7, omitted, to the 4, we have the remainder 47, under which setting the *given divisor* 120, we have $\frac{47}{120}$ to annex to the quotient.

3. To divide 14723 by 100, we take the two figures 23 from the right of the dividend, for the *remainder*, and the other figures 147 for the *quotient*.

Hence the *complete* quotient is $147\frac{23}{100}$.

☞ The figures of the dividend first taken in dividing, have a *local value* 10 times, or 100 times, &c., their *simple value*, according as *one*, or *two*, &c., figures follow them on the right (§ 16); and the first quotient figure must therefore have 10 *times*, or 100 *times*, &c., its simple value. The proper local value is assigned to the quotient figure, by the succeeding quotient figures,—these being always just as many as the succeeding figures of the dividend. In like manner each quotient figure receives its proper value.

The *excess* belonging to any particular place in the dividend, is so many *tens* in the next place on the right (§ 11); and is made *tens* to the next figure by prefixing it to that figure.

In the second example, we divided 12 in 1312, instead of 120 in 13127. But 120 is 10 times 12, and 13127 is 13120+7, or 10 times 1312,+7; and 12 in 1312 gives the same quotient as 10 times 12 in 10 times 1312 (§ 57).

In the same way it may be shown that any number of 0s may be omitted in the right of the divisor, if an equal number of figures be omitted in the right of the dividend. ☜

The Operation Proved.

§ 59. Division may be *verified* or *proved*, by multiplying the divisor and quotient together, and adding the remainder, if any, to the product; the result must be equal to *the dividend.*

EXERCISES.

1. How many barrels of apples, at 2 dollars per barrel, may be bought for 150 dollars?

The number of barrels that may be bought, is the number of times that 2 dollars *is contained in* 150 dollars (§ 53).

Ans. 75 barrels.

2. At 3 dollars per yard, how many yards of broadcloth may be purchased for 387 dollars? *Ans.* 129 yards.

3. How many cords of wood, at 4 dollars per cord, may be purchased for 600 dollars? *Ans.* 150 cords.

4. At 5 dollars apiece, how many superfine beaver hats may be purchased for 3700 dollars? *Ans.* 740 hats.

5. How many dozen of shoes, at 6 dollars per dozen, may be purchased for 750 dollars? *Ans.* 125 dozen.

6. There being 7 days in a week, it is required to find how many weeks there are in 728 days? *Ans.* 104 weeks.

7. If one box will hold 80 pair of shoes, how many of such boxes will be required to contain 1840 pair? *Ans.* 23 boxes.

8. At the rate of 900 dollars each, how many dwelling houses could be built for 11700 dollars? *Ans.* 13 houses.

9. At 11 dollars each per month, how many laborers could be hired a month for 2530 dollars? *Ans.* 230 laborers.

10. At 120 dollars apiece, how many fine horses could I purchase for the sum of 4200 dollars? *Ans.* 35 horses.

11. What quantity of flour could be bought for 3 dollars, when the price is 5 dollars per barrel?

One dollar would buy $\frac{1}{5}$ *of a barrel; hence* 3 *dollars would buy* $\frac{3}{5}$ *of a barrel.*

Or, 3 *dollars would buy the* same part *of a barrel that* 3 *dollars is of* 5 *dollars:* 3 *dollars is* $\frac{3}{5}$ *of* 5 *dollars* (§ 47).

Ans. $\frac{3}{5}$ of a barrel.

12. At the rate of 15 dollars per ton, what quantity of hay could be bought for 7 dollars? *Ans.* $\frac{7}{15}$ of a ton.

13. If land sell at the rate of 50 dollars per acre, what quantity of land could be purchased for 17 dollars?

Ans. $\frac{17}{50}$ of an acre.

14. A ferryboat is valued at 100 dollars. What share or interest in the boat could be purchased for 37 dollars?

Ans. $\frac{37}{100}$ of it.

15. A person who undertook a journey of 425 miles, having traveled 89 miles; what part of the journey has he accomplished? *Ans.* $\frac{89}{425}$ of it.

16. A manufactory is estimated to be worth 12000 dollars. What interest in it could be purchased for 2143 dollars?

Ans. $\frac{2143}{12000}$ of it.

17. What quantity of cloth, at 10 dollars a yard, ought I to have for 503 dollars?

The divisor being 10 *we omit the* 3 *in the right of the dividend,* 503, *and thus find* 10 *in* 503, 50 times, *with remainder* 3.

The quotient is therefore $50\frac{3}{10}$.

The 50 *times* 10 *in* 503 *gives* 50 *yards, and the* 3 *dollars over will buy* $\frac{3}{10}$ *of a yard.* *Ans.* $50\frac{3}{10}$ yards.

18. At 3 dollars per cord, what quantity of wood might be bought for 175 dollars? *Ans.* $58\frac{1}{3}$ cords.

19. At the rate of 7 miles an hour, how many hours would a stage coach be in running 975 miles? *Ans.* $139\frac{2}{7}$ hours.

20. Allowing a workman to build 9 rods of fence in a day, how many days would he require to build 1603 rods? *Ans.* $178\frac{1}{9}$ days.

21. How many tons of hay, at 11 dollars per ton, may be purchased for 3071 dollars? *Ans.* $279\frac{2}{11}$ tons.

22. How many acres of land, at 40 dollars per acre, may be bought for 7309 dollars? *Ans.* $182\frac{29}{40}$ acres.

23. How many tons of steel, at 120 dollars per ton, may be bought for the sum of 1577 dollars? *Ans.* $13\frac{17}{120}$ tons.

24. Allowing 30 days to make a month, how many months would there be in 200 days+177 days? *Ans.* $12\frac{17}{30}$ months.

25. A has 2345 dollars, and B 3000 dollars. What quantity of land can the two together purchase, at the rate of 50 dollars per acre? *Ans.* $106\frac{45}{50}$ acres.

26. A farmer sold beef for 130 dollars, and pork for 200 dollars. With the proceeds of these sales, he wishes to purchase corn at 3 dollars per barrel; what quantity can he buy? *Ans.* 110 barrels.

27. A merchant sold cloth for 423 dollars, cotton for 125 dollars, and silk for 300 dollars; and invested the proceeds in sugar at 12 dollars per barrel. How many barrels of sugar did he buy? *Ans.* $70\frac{8}{12}$ barrels.

28. If 5 acres of ground sell for 163 dollars, what is the price per acre?

One acre being $\frac{1}{5}$ *of* 5 *acres, is worth* $\frac{1}{5}$ *of* 163 dollars; *which is* 163 dollars$\div$5 (§ 51 and 54). *Ans.* $32\frac{3}{5}$ dollars.

29. If a man travels 200 miles in 6 days, at what rate does he travel per day? *Ans.* $33\frac{2}{6}$ miles.

30. If 7 head of horses sell for 850 dollars, what will be the average sum received for each? *Ans.* $121\frac{3}{7}$ dollars.

31. Allowing 1703 acres of land to be divided into 8 farms of equal size, what will be the number of acres in each? *Ans.* $212\frac{7}{8}$ acres.

32. If 100 yards of linen cost 57 dollars, what is the price per yard?

One yard costs $\frac{1}{100}$ of 57 *dollars*, or 57 *dollars*$\div$100; *which is*, $\frac{57}{100}$ of a dollar (§ 47 and 51). *Ans.* $\frac{57}{100}$ of a dollar.

33. If 50 bushels of corn sell for 13 dollars, what is the selling price per bushel? *Ans.* $\frac{13}{50}$ of a dollar.

34. If 3 plantations of equal value sell for 8491 dollars, what sum would be received for each? *Ans.* 2830$\frac{1}{3}$ dollars.

35. If 8 yards of Irish linen amount to 7 dollars, at what price per yard does the linen sell? *Ans.* $\frac{7}{8}$ of a dollar.

36. If the construction of 4 bridges on a turnpike road, cost 14803 dollars, what is the average cost of each?
Ans. 3700$\frac{3}{4}$ dollars.

37. Allowing 600 acres of ground to produce 24000 bushels of wheat, what would be the produce per acre?
Ans. 40 bushels.

38. Allowing 900 barrels of flour to sell for 9900 dollars, what would be the selling price per barrel? *Ans.* 11 dollars.

39. A capital stock of 225000 dollars is held in 1000 equal shares. What is the amount of each share?
Ans. 225 dollars.

40. A farmer has 70 acres of land worth 2450 dollars, and 110 acres worth 4500 dollars. What is the whole worth, and what is each tract worth per acre?
Ans. The whole, 6950 dollars;
The 1st, 35 dollars, and
The 2d, 40$\frac{10}{11}$ dolls. per acre.

41. A drover bought 54 head of cattle at one time, and 66 head at another time,—the whole amounting to 1800 dollars. What was the average cost per head? *Ans.* 15 dollars.

42. A planter bought 7 mules at 35 dollars apiece, 4 at 40 dollars apiece, and 9 at 37 dollars apiece. What sum was paid for all, and what was the average sum paid for each?
Ans. 738 dollars for all; and 36$\frac{18}{20}$ for each.

43. In how many days could 10 men accomplish the same amount of work that one man could do in 349 days?

10 *men could do the work in* $\frac{1}{10}$ of the time *in which* 1 *man would do it; that is, in* $\frac{1}{10}$ *of* 349 days. *Ans.* 34$\frac{9}{10}$ days.

44. In how many days ought 7 masons to build a wall which one mason could build in 175 days? *Ans.* 25 days.

45. How long ought 20 men to subsist on a stock of provisions which would suffice one man 433 days? *Ans.* 21$\frac{13}{20}$ days.

46. How long ought 12 horses to be fed on a quantity of oats which would be sufficient for 1 horse 185 days?
Ans. 15$\frac{5}{12}$ days.

47. How long might 30 workmen be employed for a sum of money which would pay 1 workman for 401 days?

Ans. 13$\frac{11}{30}$ days.

48. In how many days could 10 men accomplish the same amount of work that 13 men could do in 349 days?

1 *man would do the work in* 13 times 349 days, *and* 10 *men would do it in* $\frac{1}{10}$ of the time *in which* 1 *man would do it.*

Ans. 453$\frac{7}{10}$ days.

49. If 34 men can raise the walls of a fortification in 27 days, in how many days could 20 men do the same?

Ans. 45$\frac{18}{20}$ days.

50. How long should 12 teams be employed in doing an amount of hauling which   teams could accomplish in 65 days?

Ans. 124$\frac{7}{12}$ days.

51. Allowing that 75 laborers could pave a street in 123 days, in how many days could 120 laborers pave the street?

Ans. 76$\frac{105}{120}$ days.

52. A merchant bought 20 yards of cloth for 143 dollars; and, at another time, 30 yards for 165 dollars. At what price per yard was each purchase made?

Ans. The 1st, 7$\frac{3}{20}$, and
The 2d, 5$\frac{15}{30}$ dollars.

53. A farmer sold his farm containing 273 acres, at 35 dollars per acre, and immediately invested the proceeds in another farm at 50 dollars per acre. How many acres did he buy?

Ans. 191$\frac{5}{50}$ acres.

54. A plantation containing 1200 acres, was exchanged for another containing 1000 acres, and worth 53 dollars per acre. At what price per acre was the first plantation rated?

Ans. 44$\frac{200}{1200}$ dollars.

55. A gentleman having on hand 5000 dollars, took 2300 dollars to purchase bank stock, at 100 dollars a share, and divided the remainder equally among three benevolent institutions. How many shares of stock did he purchase, and what sum did each institution receive?

Ans. 23 shares; and each inst'n rec'd 900 dollars.

56. Find the Quotient of 437630÷9. *Ans.* 48625$\frac{5}{9}$.
57. Find the Quotient of 873007÷11. *Ans.* 79364$\frac{3}{11}$.
58. Find the Quotient of 703687÷20. *Ans.* 35184$\frac{7}{20}$.
59. Find the Quotient of 937863÷110. *Ans.* 8526$\frac{3}{110}$.
60. Find the Quotient of 768377÷120. *Ans.* 6403$\frac{17}{120}$.
61. Find the Quotient of 3800370÷300. *Ans.* 12667$\frac{270}{300}$.
62. Find the Quotient of 70307600÷700. *Ans.* 100439$\frac{300}{700}$.

RULE VIII.

§ 60. *To Divide by any Number exceeding* 12, *and containing two or more* SIGNIFICANT FIGURES.

1. Take figures enough in the left of the dividend to contain the divisor, and *on the right* set the number of times the divisor goes therein.

2. Multiply the divisor by the quotient figure, and subtract the product from *those figures of the dividend* which were taken in dividing.

3. Bring down the next figure of the dividend, annexing it to the *remainder*, if any. Divide into the number so obtained, and set the quotient figure on the right of the first one; if the divisor will not go in the number, set a 0 in the quotient, and bring down the next figure of the dividend.

4. Multiply the divisor by the last quotient figure—subtract the product from *the number last divided*,—bring down the next figure of the dividend, and so on.

5. *Ciphers in the right of the divisor*, and the final remainder, are to be treated as directed in RULE VII.

EXAMPLE.

To divide 210490 by 690.

$$\begin{array}{l} 69|0)21049|0(305\tfrac{40}{690}. \\ \qquad\;\; 207 \\ \hline \qquad\qquad 349 \\ \qquad\qquad 345 \\ \hline \qquad\qquad\quad 40 \end{array}$$

Omitting the 0 in the right of the divisor, and one figure in the right of the dividend, we say

69 in 210, 3 times, and set the 3 on the right; multiplying the 69 by 3, we get 207; subtracting 207 from 210, the remainder is 3; annexing the 4 from the dividend to the remainder 3, we say 69 in 34, 0 time; annexing the 9 from the dividend, we say 69 in 349, 5 times; multiplying 69 by 5, we get 345; subtracting 345 from 349, the remainder is 4, to which annexing the 0 omitted in the dividend, the *remainder* becomes 40. Under the remainder setting the *given divisor* 690, we have $\frac{40}{690}$ to annex to the quotient.

The quotient $305\frac{40}{690}$ shows that the dividend contains the divisor 305 times, and $\frac{40}{690}$ of the divisor, besides. It is also $\frac{1}{690}$ of the dividend (§ 51).

In dividing by this method, observe that the product of the divisor and any quotient figure, must be *less than the number* from which it is *to be subtracted;* and that the remainder must always be *less than the divisor.*

☞ This Rule differs from RULE VII, only in requiring the products and remainders to be written down. By Rule VII, the divisor being a small number, the *multiplication* and *subtraction* are carried on *mentally*. Both Rules depend on the same principles. ☜

Proof by Addition.

§ **61.** The operation by the last Rule may be proved, most readily, by adding up the *remainder,* if any, and the several *products* of the divisor and quotient figures, in *the order in which they stand.* The Sum must be equal to the *dividend.*

For the preceding example the proof may be presented thus:

```
          207
           345
             40
         ------
The Sum  210490  is equal to the dividend.
```

EXERCISES.

63. Find the Quotient of 34793÷21. *Ans.* $1656\frac{17}{21}$.
64. Find the Quotient of 70370÷32. *Ans.* $2199\frac{2}{32}$.
65. Find the Quotient of 64783÷430. *Ans.* $150\frac{283}{430}$.
66. Find the Quotient of 730864÷56. *Ans.* $13051\frac{8}{56}$.
67. Find the Quotient of 207863÷340. *Ans.* $611\frac{123}{340}$.
68. Find the Quotient of 734764÷431. *Ans.* $1704\frac{340}{431}$.
69. Find the Quotient of 973100÷3220. *Ans.* $302\frac{680}{3220}$.
70. Find the Quotient of 8746346÷5473. *Ans.* $1598\frac{492}{5473}$.
71. Find the Quotient of 98300794÷3290. *Ans.* $29878\frac{2174}{3290}$.
72. Find the Quotient of 37034803÷40700. *Ans.* $909\frac{38503}{40700}$.
73. Find the Quotient of 13476390÷53001. *Ans.* $254\frac{14136}{53001}$.

74. At the rate of 32 miles per day, how many days would a person be employed in walking 3968 miles ?

The number of days will be the number of times 32 in 3968.
Ans. 124 days.

75. If 45 acres of ground sell for 1039 dollars, what is the price per acre ?

The price per acre is $\frac{1}{45}$ *of* 1039 *dollars.* *Ans.* $23\frac{4}{45}$ dollars.

76. Allowing 365 days to make a year, how many years are there in 9130 days ? *Ans.* $25\frac{5}{365}$ years.

77. In how many days could 63 men accomplish a piece of work which one man could do in 1000 days ?

Ans. $15\frac{55}{63}$ days.

78. Allowing a barrel to contain 196 pounds of flour, how many barrels could be filled with 4900 pounds ?

Ans. 25 barrels.

79. There being 1760 yards in a mile, find how many miles there are in 65129 yards. *Ans.* $37\frac{9}{1760}$ miles.

80. How many days would 21 horses subsist on an amount of food which would suffice one horse 300 days ?

Ans. $14\frac{6}{21}$ days.

81. Allowing a steamboat to run 275 miles in a day, in what time would she make a trip of 5349 miles? *Ans.* $19\frac{124}{275}$ days.

82. A has 340 head of cattle worth 9860 dollars, and B has 760 acres of land worth 32680 dollars. Required the value of A's cattle per head, and of B's land per acre.

Ans. 29 dollars; and 43 dollars.

83. Having a tract of land containing 540 acres, I wish to divide it into fields containing 45 acres each. What number of fields will it make ? *Ans.* 12 fields.

84. In how many days ought a company of 54 men to complete an excavation, if 75 men could do it in 150 days ?

Ans. $208\frac{18}{54}$ days.

85. A company of 100 men have provisions sufficient for 4 months. If 33 men depart from the company, how long will the same provisions suffice the remainder ?

After 33 *men depart,* 67 *men will remain. The question, then, is, how long may* 67 *men subsist on provisions which would support* 100 *men for* 4 *months.* *Ans.* $5\frac{65}{67}$ months.

86. If 27 barrels of flour be worth 135 dollars, what are 350 barrels worth, at the same price per barrel ?

One barrel is worth 135 dollars÷27; *and* 350 *barrels are worth* 350 times *as much as one barrel is worth.* *Ans.* 1750 dollars.

87. If 39 acres of ground produce 2184 bushels of corn. how many bushels will 280 acres produce at the same rate ?

Ans. 15680 bushels.

88. A merchant bought 250 yards of cloth for 1750 dollars, and sold 133 yards of it at the same price at which he bought it. What did the cloth sold amount to ? *Ans.* 931 dollars.

89. What sum of money ought a workman to earn in 503 weeks, allowing that in 297 weeks he could earn 3861 dollars?

Ans. 6539 dollars.

90. A farmer has 10 head of horses, and oats enough to feed them for 5 months. If he purchase 3 more horses, how long will his oats suffice to feed the whole number?

Ans. $3\frac{11}{13}$ months.

91. A gentleman having on hand 6975 dollars, bought 5 pair of oxen, at 45 dollars a pair, and, with the remainder of the sum, purchased 230 acres of land. What was the price of the land per acre? *Ans.* $29\frac{80}{230}$ dollars.

92. A person who undertook a journey of 1000 miles, traveled the first 7 days at the rate of 35 miles per day. How long will he be in accomplishing the remaining distance, at the rate of 33 miles per day? *Ans.* $22\frac{29}{33}$ days.

93. A planter has 2280 dollars to lay out for mules and oxen, and wishes to purchase the same number of each. If he pay 65 dollars a head for mules, and 30 for oxen, how many of each can he buy?

$65+30=95$. *Then* 95 *dollars will buy* 1 mule and 1 ox; *and the number of times* 95 *in* 2280 *will be the number required.*

Ans. 24 of each.

94. How many yards of cloth at 7 dollars a yard, 8 dollars a yard, and 9 dollars a yard,—the quantity of each kind to be the same,—can a merchant buy for 1800 dollars?

Ans. 75 yards of each kind.

95. A cistern, the capacity of which is 10000 gallons, is to be filled with water by 3 pipes discharging into it. The first pipe discharges 200 gallons per hour, the second and third each 150 gallons per hour. In what time will the cistern be filled by the three pipes running together? *Ans.* 20 hours.

96. Another cistern, the capacity of which is 15000 gallons, is supplied with water by two pipes, each discharging 325 gallons, per hour; but, by leakage, the cistern loses 100 gallons per hour. In what time would the two pipes, running together, fill the cistern? *Ans.* $27\frac{150}{550}$ hours.

97. Allowing the Moon to be 240 thousand miles from the Earth, and the Sun 95 millions of miles from the Earth; how many times the Moon's distance from us is that of the Sun?

Ans. $395\frac{200000}{240000}$ times.

98. The velocity of light being 192 thousand 500 miles per second, and the distance from the Sun to the Earth 95 millions of miles; how many seconds does light require to pass from the Sun to the Earth? *Ans.* $493\frac{97500}{192500}$ seconds.

EXERCISES ON CHAPTER II.

Sign of Aggregation.

§ 62. A *parenthesis* ( ) is used to denote the *Aggregate* of the inclosed expression; and this aggregate connects with whatever *sign* immediately precedes or follows the parenthesis.

Thus $(13+7)\times 5$ denotes the *sum* of 13 and 7 multiplied by 5; that is, 20×5.

1. Find the *value of the expression*,
$(246+34+9+16+1)\times 4$. *Ans.* 1224.

2. Find the value of the expression,
$(370+65+100+3-90)\times 5$. *Ans.* 2240.

3. Find the value of the expression,
$(500+18+73+25+19)\times(7-2)$. *Ans.* 3175.

4. Find the value of the expression,
$(7348+400-100)\times(437-129)$. *Ans.* 2355584.

5. Find the value of the expression,
$(97746+305+20)\div(320+30)$. *Ans.* $280\frac{71}{350}$.

6. Find the value of the expression,
$(4093757-307609)\times(5083-3)$. *Ans.* 19233631840.

7. Find the value of the expression,
$(73017600-189976)\div(763+7)$. *Ans.* $94581\frac{254}{770}$.

8. Find the value of the expression,
$(83073769+23764)\times(7307-4)$. *Ans.* 606861283499.

9. Find the value of the expression,
$(7360793-283746+3848-500)\div(75013-113)$.
Ans. $94\frac{39795}{74900}$.

10. The sum of two numbers being 35745, and one of the numbers 1740, what is the other number? *Ans.* 34005.

11. The difference of two numbers being 13000, and the less number 635, what is the greater number? *Ans.* 13635.

12. The difference of two numbers being 37073, and the greater number 739860, what is the less number?
Ans. 702787.

13. The product of two numbers being 96350, and one of the numbers 470, what is the other number? *Ans.* 205.

Two Numbers Found from their Sum and Difference.

§ 63. The Sum+the *difference* of two numbers is TWICE the *greater number;* and the Sum—the *difference* of two numbers, is TWICE the *less number.*

For example, take the numbers 10 and 6.

Their *sum* 16+their *difference* 4 is 20, which is *twice* 10. and their sum 16—their difference 4 is 12, which is *twice* 6.

14. The sum of two numbers is 80, and their difference is 20. What is the greater, and what the less number?

80+20 is 100, *twice* the *greater;* and 80—20 is 60, *twice* the *less; hence the greater number is* $\frac{1}{2}$ of 100, *and the less is* $\frac{1}{2}$ of 60.
Ans. 50 and 30.

15. The sum of two numbers is 1000, and their difference is 200. What are the two numbers? *Ans.* 600 and 400.

16. The sum of two numbers being 1840, and their difference 500,—what are the two numbers? *Ans.* 1170 and 670.

17. The product of two numbers being 11600 and the multiplicand 80, what is the multiplier? *Ans.* 145.

18. The product of two numbers being 46400, and the multiplier 240, what is the multiplicand? *Ans.* $193\frac{80}{240}$.

19. The dividend being 23200, and the quotient 160, what is the divisor?

The *dividend* is a *product*, and the *quo.* a *factor*. *Ans.* 145.

20. The sum of 1728 dollars having been divided equally among a number of men, each man received 24 dollars. What was the number of men? *Ans.* 72 men.

21. A and B together have 2300 dollars, and A has 500 dollars more than B. What sum has each?
Ans. A has 1400, and B 900 dollars.

22. An ironmonger bought 15 tons of iron at 39 dollars per ton, and 23 tons at 37 dollars per ton. What would he gain by selling the whole at 42 dollars per ton? *Ans.* 160 dollars.

23. C and D together have 4348 dollars, and C has 375 dollars less than D. What sum has each?
Ans. C has $1986\frac{1}{2}$, and D $2361\frac{1}{2}$ dollars.

24. A merchant collected from A 230 dollars, from B 303 dollars, and from C 95 dollars. If he lay out the whole sum collected, for cloth at 7 dollars a yard, how much can he buy?
Ans. $89\frac{5}{7}$ yards.

25. A farmer wishes to fill three kinds of sacks, containing 3 bushels, 4 bushels, and 5 bushels, and the same number of each kind, with 1728 bushels of corn. How many sacks can he fill? *Ans.* 144 of each kind.

26. A farmer sold wheat for 900 dollars, corn for 274 dollars, and other produce for 329 dollars. Out of these proceeds he bought three pair of oxen at 55 dollars a pair, and paid the remainder for 65 acres of land. What did the land cost him per acre? *Ans.* $20\frac{38}{65}$ dollars.

27. A bought a building lot in town for 75 dollars, which was at the rate of 200 dollars per acre, and B purchased 3 pasture lots, each containing 13 acres, for 950 dollars. What quantity of ground was in A's lot, and what did B pay per acre? *Ans.* $\frac{75}{200}$ of an acre; and B $24\frac{14}{39}$ dollars.

28. If a person's income be 5000 dollars a year, and his expenses be at the rate of 5 dollars per day, at what rate would he save money per day,—there being 365 days in a year? *Ans.* $8\frac{255}{365}$ dollars per day.

29. An army of 5000 men have provisions for 3 months. If 1625 men be discharged, how long will the same provisions suffice for the remainder? *Ans.* $4\frac{1500}{3375}$ months.

30. A carpenter can earn 45 dollars a month, but his necessary expenditures are at the rate of 24 dollars a month. He wishes to purchase a certain lot of ground, which contains 19 acres, and is held at 35 dollars per acre. In what time can he save enough to make the purchase? *Ans.* $31\frac{14}{21}$ months.

31. A sold to B 15 cords of wood at 3 dollars per cord, 53 barrels of corn at 2 dollars per barrel, and 2 beeves at 30 dollars each. In payment, A takes 160 dollars in cash, 3 sacks of coffee at 14 dollars a sack, and 20 gallons of molasses. What did A's sales amount to, and what did the molasses cost him per gallon?

Ans. 211 dollars; and $\frac{9}{20}$ of a dollar per gallon.

CHAPTER III.

COMPOSITE NUMBERS.—PRIME FACTORS.—COMMON MEASURE.—
COMMON MULTIPLE.

COMPOSITE NUMBERS.

§ 64. A *composite* number is one which is the *product* of two factors, each greater than a *unit*.

Thus 4 is a composite number, being 2×2.

Is 6 a composite number? Is 7? Is 12? Is 19? Is 36? Is 45?

Decomposition of Numbers.

§ 65. *Decomposing a number* consists in resolving the number into *its factors*.

Thus 6 is decomposed when resolved into the factors 3 and 2.

Into what *two factors* may 15 be resolved? 21? 33? 84? 99?
Into what *three* factors may 24 be resolved? 30? 70? 36? 100?

§ 66. In Division, the *dividend is resolved into two factors*, one of which is the divisor, and the other the quotient.

Taking 4 as a factor of 20, what is the other factor? 7 being one factor of 56, what is the other factor? 9 being one factor of 108, what is the other factor? 12 being one factor of 144, what is the other factor?

Any number whatever may be resolved into *itself multiplied by a unit*.

Thus 5 is 5×1; 7 is 7×1, &c.

Sign of Equality.

§ 67. The *sign* =, *equal to*, placed between two numbers, or numerical expressions, signifies that they are *equal to each other*.

Thus 12+8=4×5 signifies that the sum of 12 and 8 is *equal to* the product of 4 and 5; and is read 12 *plus* 8 *is equal to* 4 *into* 5.

Constant Product of Several Factors.

§ 68. The Product of several factors remains *the same* in *whatever order* the factors are multiplied together.

Take, for example, the product $2\times3\times5$.

Since $2\times3=3\times2$, we have $2\times3\times5=3\times2\times5$; and since $2\times5=5\times2$, we have $3\times2\times5=3\times5\times2$; and so on, there being *six* different ways in which the factors may be multiplied together.

Division by the Canceling of Factors.

§ 69. A Product is divided by *either* of its *factors* by *canceling* that factor; or by the *product* of any two or more of its factors, by canceling those factors.

For example, take $30=2\times3\times5$.

If we divide it by 2, the quotient will be 3×5, or 15; and if we divide it by 2×3, or 6, the quotient will be 5 (§ 66).

If the product is to be divided by *itself,* all its factors must be canceled, and their place supplied by a *unit;* for a number is contained in itself *once.*

The cancellation of a number is denoted by a *line drawn across it.* Thus $\cancel{2}\times3\times5$ denotes that the 2 in this product is *canceled,* which is equivalent to dividing said product by 2.

COMPOSITE MULTIPLIERS AND DIVISORS.

When a multiplier or divisor can be resolved into factors, each of which shall be a *number not exceeding* 12, or such number with 0s annexed, it will sometimes shorten the operation to multiply or divide by means of such factors.

RULE IX.

§ 70. *To multiply by means of* FACTORS.

Resolve the multiplier into two or more factors; multiply by one of the factors, and the *product thence arising* by another factor; and so on, until all the factors are employed. The last product will be the one required.

EXAMPLE.

To multiply 345 by 18.

Resolving 18 into the factors 3 and 6, we have $345\times3=1035$; and $1035\times6=6210$.

Then $345\times18=345\times3\times6=6210$ (§ 68).

EXERCISES.

In performing these exercises, use the *factors* of the multiplier.

1. Required the value of 147 shares of rail-road stock, at the rate of 96 dollars per share. *Ans.* 14112 dollars.

2. Allowing 63 gallons to fill a hogshead, how many gallons will be required to fill 183 hogsheads? *Ans.* 11529 gallons.

3. A planter sold 230 bales of cotton at an average of 32 dollars per bale. What sum did he receive for his cotton? *Ans.* 7360 dollars.

4. Allowing a ship to sail at the rate of 117 miles per day, how many miles would she sail in 108 days? *Ans.* 12636 miles.

5. If 56 masons could build a certain wall in 310 days, in how many days could one mason build the same wall? *Ans.* 17360 days.

6. If 132 clerks can accomplish a certain amount of writing in 51 days, in what time could one clerk accomplish 3 times as great an amount of writing? *Ans.* 20196 days.

7. A gentleman purchased 42 bales of cotton cloth,—each bale containing 31 pieces, and each piece containing 36 yards. Required the number of yards that he purchased? *Ans.* 46872 yards.

8. A speculator bought a tract of land containing 1200 acres, at 72 dollars per acre; and afterwards sold *one fifth* of the tract at 96 dollars per acre. What did he gain on the part sold? *Ans.* 5760 dollars.

RULE X.

§ 71. *To divide by means of* FACTORS.

1. Resolve the divisor into two or more factors; divide by one of the factors, and the *quotient thence resulting* by another factor, and so on, until all the factors are employed. The last quotient will be the one required.

2. If a remainder occur in the first division, and in none succeeding it, it is the *true remainder.*

3. If a remainder occur in the second division, and in none succeeding it, multiply it by the first divisor, and to the product add the first remainder, if any, for the *true remainder.*

4. *If three or more factors be used,* multiply the last remainder by the preceding divisor, and to the product add the corresponding remainder, if any; multiply the sum by the next preceding divisor, adding as before; and so on, until the divisors are all included, for the *true remainder.*

EXAMPLE.

To divide 273 by 36.

$$\begin{array}{r@{\,}l} 4)\underline{273} & \\ 9)\underline{68} & \text{times, 1 over.} \\ 7 & \text{times, 5 over.} \end{array}$$

Quotient 7, true remainder 21; or quotient $7\frac{21}{36}$.

Resolving 36 into 4×9, we divide first by 4, and the quotient 68 thence resulting by 9, and obtain 7, the quotient required.

To find the true remainder, we multiply the second remainder 5, by the first divisor 4, and add the first remainder 1. Thus $5\times4=20$, and 1 makes 21.

☞ The divisor 4 is only *one ninth* of the whole divisor 36; hence it is contained in the dividend 9 *times* as often as 36 is. The true quotient is then $\frac{1}{9}$ of that found for the divisor 4.

A remainder after the first division is so many *units of the dividend.* A remainder after the second division is so many *units of the first quotient;* and since the *first quotient* × the *first divisor* produces the *dividend,* a remainder of the first quotient × the first divisor produces the corresponding *remainder of the dividend.* This remainder added to the first one, gives the true remainder of the dividend. ☜

EXERCISES.

In performing these exercises, use the *factors* of the divisor.

1. A hogshead of ale or beer contains 54 gallons; how many hogsheads then will be filled by 9479 gallons? *Ans.* $175\frac{29}{54}$ hogsheads.

2. If 81 men take equal shares of 13846 dollars, how many dollars will be the share of each man?

How will you find the answer to this question? How do you find $\frac{1}{81}$ of any number? *Ans.* $170\frac{76}{81}$ dollars.

3. Allowing a person to travel at the rate of 45 miles per hour, how long will he be in going 586 miles? *Ans.* $13\frac{1}{45}$ hours.

4. Supposing 49 fat cattle to sell for 1975 dollars, what would be the average price for each? *Ans.* $40\frac{15}{49}$ dollars.

5. If one man can reap a field of hemp in 19 days, in what time ought 14 men to reap the same field? *Ans.* $1\frac{5}{14}$.

6. In what time ought 72 men to accomplish the same amount of work that 9 men could do in 300 days? *Ans.* $37\frac{36}{72}$ days.

7. If 77 cords of wood be purchased for 231 dollars, for what sum ought 521 cords to be bought at the same rate? *Ans.* 1563 dollars.

8. Allowing 144 yards of cloth to sell for 864 dollars, what sum should be received for double the quantity of cloth, at double the price per yard? *Ans.* 3456 dollars.

9. A garrison of 140 men has provisions sufficient for 54 days. If 8 of the men depart, how long will the same provisions suffice the remainder of the garrison?

Ans. $57\frac{36}{132}$ days.

PRIME FACTORS.

§ **72.** A *prime* number is one which cannot be resolved into two factors, each greater than a *unit;* thus 3 is a *prime* number.

Is 5 a *prime* or a *composite* number? Is 8? Is 11? Is 15? Is 23? Name all the *prime* numbers, in succession from 1 to 23.

§ **73.** Every *composite* number may be resolved into *prime factors;* that is, into factors each of which shall be a prime number.

For example, 30 may be at once resolved into 3×10; then resolving 10 into 2×5, we have 30=3×2×5; and 3, 2, and 5 are prime numbers.

What are the prime factors of 8? Of 20? Of 24? Of 36? Of 63? Of 16? Of 21? Of 27? Of 33? Of 100? Of 1000?

Table of Prime Numbers above 23.

This table, which might be extended without limit, may be useful to the pupil, by way of reference, in the application of subsequent Rules.

29	107	199	311	421	541	647	769	883	1019	1129	1279	1427	1543	1663	1801	1951
31	109	211	313	431	547	653	773	887	1021	1151	1283	1429	1549	1667	1811	1973
37	113	223	317	433	557	659	787	907	1031	1153	1289	1433	1553	1669	1823	1979
41	127	227	331	439	563	661	797	911	1033	1163	1291	1439	1559	1693	1831	1987
43	131	229	337	443	569	673	809	919	1039	1171	1297	1447	1567	1697	1847	1993
47	137	233	347	449	571	677	811	929	1049	1181	1301	1451	1571	1699	1861	1997
53	139	239	349	457	577	683	821	937	1051	1187	1303	1453	1579	1709	1867	1999
59	149	241	353	461	587	691	823	941	1061	1193	1307	1459	1583	1721	1871	2003
61	151	251	359	463	593	701	827	947	1063	1201	1319	1471	1597	1723	1873	2011
67	157	257	367	467	599	709	829	953	1069	1213	1321	1481	1601	1733	1877	2017
71	163	263	373	479	601	719	839	967	1087	1217	1327	1483	1607	1741	1879	2027
73	167	269	379	487	607	727	853	971	1091	1223	1361	1487	1609	1747	1889	2029
79	173	271	383	491	613	733	857	977	1093	1229	1367	1489	1613	1753	1901	2039
83	179	277	389	499	617	739	859	983	1097	1231	1373	1493	1619	1759	1907	2053
89	181	281	397	503	619	743	863	991	1103	1237	1381	1499	1621	1777	1913	2063
97	191	283	401	509	631	751	871	997	1109	1249	1399	1511	1627	1783	1931	2069
101	193	293	409	521	641	757	877	1009	1117	1259	1409	1523	1637	1787	1933	2081
103	197	307	419	523	643	761	881	1013	1123	1277	1423	1531	1657	1789	1949	2083

RULE XI.

§ 74. *To resolve a* COMPOSITE *number into its prime factors.*

1. Divide the given number by any *prime number* that will divide it without a remainder; divide the quotient in like manner; and so on, until the quotient becomes a prime number.

2. The *several divisors* and the last *quotient* will be the prime factors required.

3. If the given number can only be divided by *itself*, or a *unit*, without a remainder, it is itself a prime number.

EXAMPLE.

To resolve 210 into its prime factors.

$$\begin{array}{r|l} 2 & 210 \\ \hline 3 & 105 \\ \hline 5 & 35 \\ \hline & 7 \end{array}$$

The prime divisor 2 resolves 210 into 2×105 (§ 66). The divisor 3 resolves 105 into 3×35; and the divisor 5 resolves 35 into 5×7.

Hence 210 is resolved into the prime factors, 2, 3, 5, and 7.

EXERCISES.

1. Resolve 735 into its *prime factors*. *Ans.* 5, 7, 3, and 7.
2. Resolve 330 into its prime factors. *Ans.* 2, 3, 5, and 11.
3. Resolve 510 into its prime factors. *Ans.* 2, 3, 5, and 17.
4. Resolve 390 into its prime factors. *Ans.* 5, 2, 3, and 13.
5. Resolve 550 into its prime factors. *Ans.* 5, 2, 5, and 11.
6. Resolve 930 into its prime factors. *Ans.* 2, 3, 5, and 31.
7. Resolve 1330 into its prime factors. *Ans.* 2, 5, 7, and 19.
8. Resolve 1610 into its prime factors. *Ans.* 2, 5, 7, and 23.
9. Resolve 4350 into its prime factors. *Ans.* 2, 3, 5, 5, and 29.
10. Resolve 6020 into its prime factors. *Ans.* 2, 2, 5, 7, and 43.

The application of the preceding Rule will be seen in finding Common Measures, and Common Multiples.

COMMON MEASURE.

§ 75. One number is called a *measure* of another, if it is contained in the other an exact number of times, without *a remainder*.

Thus 2 is a *measure* of 6, and 3 is also a measure of 6.

Name a measure of 15? Of 35? Of 72? Of 99? Of 132?

If a number can be *measured by* 2, it is called an *even number;* otherwise, it is an *odd number*.

Name all the *even* numbers to 50. The *odd* numbers to 55.

§ 76. A *common measure* of two or more numbers, is any number which will *measure each of them;* that is, divide each of them without a remainder.

Thus 3 is a *common* measure of 12 and 15.

Name a common measure of 18 and 27. Of 20 and 35. Of 32 and 48. Of 12, 18, and 30. Of 36, 54, and 72.

A common measure, it is evident, is any *factor* which is *common* to the given numbers; that is, any *factor found in each of them*.

Greatest Common Measure.

§ 77. The *greatest common measure* of two or more numbers, is the greatest number that will measure each of them; that is, divide each of them without a remainder.

Thus 9 is the greatest common measure of 18 and 27.

What is the greatest common measure of 16 and 24? Of 30 and 40? Of 36 and 48? Of 64 and 12? Of 8, 12, and 32?

What is the greatest common measure of 20 and 30? Of 25 and 35? Of 24 and 72? Of 15 and 40? Of 12, 36, and 60?

When two numbers have *no common measure* greater than a *unit*, they are said to be *prime to each other;* thus 16 and 21 are *prime to each other*.

A common measure is sometimes, though not so properly, called a common *divisor;* and the *greatest* common measure, the *greatest* common divisor.

RULE XII.

§ 78. *To find the* COMMON MEASURES *of two or more numbers.*

1. Resolve each number into its *prime factors*, and select all the factors which are *common to the several numbers*, that is, which are found in each number.

2. Any *one*, or the product of any *two* or *more*, of these common factors, will be *a common measure*—and the product of *all the common factors* will be the *greatest* common measure of the given numbers.

EXAMPLE.

To find the *common measures* of 30, 45, and 75.

Resolving each number into its prime factors, we find

$30=2\times3\times5$; $45=3\times3\times5$; and $75=3\times5\times5$ (§ 74).

The factors which are *common to the three numbers*, are 3 and 5; then 3 and 5 are each a common measure, and $3\times5,=15$, is the greatest common measure of 30, 45, and 75.

It is plain that both 3 and 5 will divide each of the given numbers, without a remainder, as will also $3\times5=15$; and this last is the greatest number that will so divide them (§ 69).

EXERCISES.

1. Find the greatest *common measure* of 252, 180, and 288. *Ans.* 36.
2. Find the greatest common measure of 120, 144, and 168. *Ans.* 24.
3. Find the greatest common measure of 240, 336, and 432. *Ans.* 48.
4. Find the greatest common measure of 392, 504, and 560. *Ans.* 56.
5. Find the greatest common measure of 504, 567, and 630. *Ans.* 63.
6. Find the greatest common measure of 336, 588, and 756. *Ans.* 84.
7. Find the greatest common measure of 288, 480, and 672. *Ans.* 96.
8. Find the greatest common measure of 460, 1035, and 1150. *Ans.* 115.
9. Find the greatest common measure of 620, 1116, and 1488. *Ans.* 124.
10. Find the several common measures of 42, 210, and 126, *Ans.* 2, 3, 7, 6, 14, 21, and 42.

Another Method of Finding the Greatest Common Measure.

§ **79.** The greatest common measure of the *divisor* and *dividend* is the same as that of the *divisor* and the *remainder*, if any, after division.

Or, more generally,

§ **80.** The greatest common measure of two or more numbers, is the same as that of the *least* of those numbers and the *remainder*, or remainders, if any, after dividing the least number into the other, or each of the others.

For example, take the numbers, 12, 28, and 42,

or 12, *twice* 12+4, and 3 *times* 12+6.

It is plain that every *measure* of 12 is also a measure of *twice* 12, and of 3 *times* 12; hence no number can measure 12, *twice* 12+4, and 3 *times* 12+6, unless it also measures 4 and 6; the greatest common measure, therefore, of 12, 4, and 6, will be the greatest common measure of 12, 28, and 42; and 4 and 6 are the remainders after dividing 12, into 28, and 42.

On this principle is founded

RULE XIII.

§ **81.** *To find the greatest common measure of two or more numbers.*

1. *For two given numbers,*—divide the less number into the greater, and the remainder into the divisor, and the last remainder into the last divisor, and so on, until there is no remainder. The last *divisor* will be the common measure required.

2. *For three or more numbers,*—divide the least number into each of the others, and take the remainders and divisor for a new set of numbers, with which proceed as before, and so on, until there is no remainder. The last divisor will be the common measure required.

EXAMPLE.

To find the greatest common measure of 135 and 720.

135)720(5
675
45)135(3

We divide 135 into 720, and the remainder 45 into the divisor 135, when we get no remainder. The last divisor 45 is the greatest common measure of 135 and 720.

☞ By the principle of § 79, the greatest common measure of 135 and 720 is the same as that of 135 and 45, which is evidently 45.

The same principle generalized for *two or more numbers*, establishes, in like manner, the 2d part of the Rule. ☜

EXERCISES.

1. Find the greatest *common* measure of 324 and 480. *Ans.* 12.

2. Find the greatest common measure of 972 and 1260. *Ans.* 36.

3. Find the greatest common measure of 744 and 1680. *Ans.* 24.

4. Find the greatest common measure of 480 and 960. *Ans.* 480.

5. Find the greatest common measure of 636 and 1080. *Ans.* 12.

6. Find the greatest common measure of 375 and 1100. *Ans.* 25.

7. Find the greatest common measure of 120 and 1440. *Ans.* 120.

8. Find the greatest common measure of 780 and 1560. *Ans.* 780.

APPLICATION OF COMMON MEASURE.

1. A farmer has 66 bushels of corn, and 90 of wheat, which he wishes to put into sacks of equal size, and without mixing the two kinds of grain. How many bushels must each sack contain?

The size of each sack will evidently be any common measure of 66 and 90. *Ans.* 2 bushels, 3 bushels, or 6 bushels.

2. A gentleman has a corner of ground, the sides of which measure 225 feet, 297 feet, and 369 feet. He wishes to enclose it with a fence having panels of uniform length; what must be the length of each panel? *Ans.* 9 feet.

3. An upholsterer has 125 yards of carpeting of one kind, 175 of another, and 225 of another. He wishes to divide the whole into pieces of equal length, and the longest that can be obtained; what must be the length of each piece? *Ans.* 25 yards.

4. Having 140 acres of land at one place, and 252 at another I wish to divide the whole into fields which shall be of equal size, and the largest that will meet such requisition. What must be the number of acres in each field? *Ans.* 28 acres.

5. Three regiments of soldiers containing, respectively, 1538 men, 2307 men, and 3845 men, are to be formed, separately, into battalions, the largest that will admit the same number of men in each. What will be the number in each battalion and the number of battalions in each regiment?

Ans. { 769 men in each battalion;
2 battal's in the 1st reg't, 3 in the 2d, and 5 in the 3d.

COMMON MULTIPLE.

§ 82. One number is called a *multiple* of another, if it can be *measured* by the other; that is, divided by it without a remainder.

Thus 6 is a *multiple* of 3; and 9 is also a multiple of 3.

Name a multiple of 5. Of 7. Of 11. Of 20. Of 50. Of 100.
Name a multiple of 8. Of 9. Of 12. Of 30. Of 60. Of 200.

§ 83. A *common multiple* of two or more numbers, is any number which can be *measured by each of them;* that is, divided by each of them without a remainder.

Thus 30 is a *common multiple* of 10 and 6.

Name a common multiple of 4 and 7. Of 3, 4, and 8. Of 5 and 9. Of 4, 3, and 6. Of 10 and 4. Of 4, 9, and 12.

Name a common multiple of 5 and 8. Of 5, 10, and 6. Of 7 and 8. Of 4, 3, and 9. Of 11 and 3. Of 4, 8, and 10.

A common multiple of two or more numbers, it is evident, is any number of which *each of the given* numbers is a *factor.*

Least Common Multiple.

§ 84. The *least common multiple* of two or more numbers, is the *least number* that can be measured by each of them; that is, divided by each of them without a remainder.

Thus 15 is the least common multiple of 3 and 5.

What is the least common multiple of 4 and 5? Of 3 and 6? Of 5, 2, and 3? Of 7 and 9? Of 6, 4, and 3? Of 8 and 12?

What is the least common multiple of 3 and 4? Of 4 and 8? Of 2, 3, and 4? Of 10 and 12? Of 1, 4, and 6? Of 10 and 20?

The least common multiple of two or more numbers is evidently the *least number* of which each of the given numbers is a *factor.*

The *product* of two or more numbers will always be *a common multiple* of the numbers, since it will have each of those numbers for a factor.

RULE XIV.

§ 85. *To find the* COMMON MULTIPLES *of two or more numbers.*

1. Resolve each number into its prime factors, and take the *smallest selection* of those factors that includes *the factors of each given number.*

2. The product of these selected factors will be the *least* common multiple; and this product multiplied by any number whatever, will be *a common* multiple, of the given numbers.

EXAMPLE.

To find the least common multiple of 6, 12, and 15.

Resolving each number into its prime factors, we have

$$6=2\times3;\ 12=2\times2\times3;\ 15=3\times5.$$

If we take 2, 3, 2, 5, we have the smallest selection of those factors that includes the factors of *each given number.*

Then $2\times3\times2\times5=60$ is the *least* common multiple of 6, 12, and 15.

And $60\times2=120$, or 60 multiplied by any other number, is a common multiple of the same numbers.

It is plain that $2\times3\times2\times5$ can be divided by each of the given numbers, without a remainder, since it includes the factors of each of them (§ 69); and it is the smallest number that can be so divided, since it is the smallest that includes the factors of each. Hence it is their least common multiple.

It is also evident that if one number be a multiple of another, any *number of times the former*, will also be a multiple of the latter.

EXERCISES.

1. Find the least *common multiple* of 10, 12, and 16. *Ans.* 240.
2. Find the least common multiple of 14, 9, and 25. *Ans.* 3150.
3. Find the least common multiple of 18, 21, and 30. *Ans.* 630.
4. Find the least common multiple of 7, 16, and 15. *Ans.* 1680.
5. Find the least common multiple of 6, 33, and 21. *Ans.* 462.
6. Find the least common multiple of 11, 15, and 32. *Ans.* 5280.
7. Find the least common multiple of 27, 44, and 4. *Ans.* 1188.
8. Find the least common multiple of 9, 18, and 20. *Ans.* 180.
9. Find the least common multiple of 8, 14, and 35. *Ans.* 280.
10. Find the common multiples of 6, 14, 20, 8, 12, and 24.
Ans. 840, 1680, 2520, &c.

Another Method of Finding the Least Common Multiple.

The preceding Rule is given to show the *composition* of the least common multiple. The following is the common Rule; and is preferable in a practical point of view.

RULE XV.

§ 86. *To find the least common multiple of two or more numbers.*

1. Set the numbers in a line, from left to right, and divide any *two or more* of them by any *prime* number, greater than a unit, that will divide them without a remainder, placing the quotient and the *undivided* numbers in a line below.

2. Divide any two or more of the numbers in the lower line, as before; and so on, until no two numbers in the lowest line, can be so divided. The product of the *divisors* and numbers in the *lowest line*, will be the least common multiple of the given numbers.

3. *If no two of the given numbers* can be divided as above, the *product of all* the given numbers will be their least common multiple.

EXAMPLE.

To find the least common *multiple* of 6, 12, and 15.

$$\begin{array}{r|rrr} 2) & 6 & 12 & 15 \\ \hline 3) & 3 & 6 & 15 \\ \hline & 1 & 2 & 5 \end{array}\quad 2\times3\times2\times5=60.$$

We divide 6 and 12 by 2; and place 15 in a line with the quotients, since 15 will not divide by two without a remainder. We then divide 3, 6, and 15, by 3; when we find that no two of the numbers, 1, 2, 5, in the lowest line, can be divided by any number greater than a *unit*, without a remainder.

Taking now the divisors, 2 and 3, and the numbers 2 and 5 in the lowest line,—omitting the 1, as not affecting the product,—we have $2\times3\times2\times5=60$, for the least common multiple of 6, 12, and 15.

☞ This method is the same *in principle* with that of Rule XIV. The divisors and numbers in the lowest line, are necessarily prime factors of the given numbers; and are the *smallest selection* of such factors that includes the factors of *each given number.* ☜

EXERCISES.

1. Find the least *common multiple* of 4, 6, 8, and 10. *Ans.* 120.

2. Find the least common multiple of 9, 3, 12, and 15. *Ans.* 180.

3. Find the least common multiple of 21, 7, 4, and 9. *Ans.* 252.

4. Find the least common multiple of 6, 4, 12, and 20. *Ans.* 60.

5. Find the least common multiple of 8, 7, 10, and 14. *Ans.* 280.

6. Find the least common multiple of 15, 2, 7, and 13. *Ans.* 2730.

7. Find the least common multiple of 24, 5, 6, and 10. *Ans.* 120.

8. Find the least common multiple of 5, 10, 13, and 24. *Ans.* 1560.

9. Find the least common multiple of 6, 7, 2, and 17. *Ans.* 714.

10. Find the least common multiple of 11, 4, 5, and 19. *Ans.* 4180.

APPLICATION OF COMMON MULTIPLE.

1. What is the smallest sum of money for which a person could purchase, either a number of mules at 32 dollars a head, or a number of cows at 14 dollars a head,—the same sum to be employed in either purchase?

It is evident that the number of dollars to be employed, is the least common multiple of 32 and 14. *Ans.* 224 dollars.

2. A can build 7 rods of fence in a day; B can build 9 rods; and C 12 rods, in a day. What amount of fencing would afford a number of whole days' work for any one of the three?
Ans. 252 rods, or 504 rods, or 756 rods, &c.

3. If one team can haul to market 10 barrels of flour; another, 12 barrels; and another, 15 barrels;—what number of barrels would make a number of full loads for any of the three teams? *Ans.* 60 barrels, or 120 barrels, or 360 barrels, &c.

4. How many bushels of wheat would fill a number of barrels, each containing 3 bushels; or a number of sacks, each containing 4 bushels; or a number of hogsheads, each containing 15 bushels;—the quantity to be the same in each case?
Ans. 60 bushels, or 120 bushels, or 180 bushels, &c.

5. What is the smallest sum for which I could purchase a number of mules, at 35 dollars a head; or a number of horses, at 45 dollars a head; and what number of each could I purchase for that sum? *Ans.* 315 dollars; 9 mules, or 7 horses.

EXERCISES ON CHAPTER III.

Find the value of each of the following expressions — multiplying and dividing by means of *factors*.

1. $(1000+250-30+375)\times(81-9)$. *Ans.* 114840.
2. $(3874-250+30-375)\times(100-4)$. *Ans.* 314784.
3. $(4800+675-84+860)\div(150-6)$. *Ans.* $43\frac{59}{144}$.
4. $(4800-675+84-860)\div(127+5)$. *Ans.* $25\frac{49}{132}$.
5. $(9999+999-75+375)\div(130-9)$. *Ans.* $93\frac{45}{121}$.

6. Resolve 436 into its prime factors.
Ans. 2, 2, and 109.
7. Resolve 780 into its prime factors.
Ans. 2, 2, 5, 3, and 13.
8. Resolve 972 into its prime factors.
Ans. 2, 2, 3, 3, 3, 3, and 3.
9. Resolve 1275 into its prime factors.
Ans. 3, 5, 5, and 17.
10. Resolve 2000 into its prime factors.
Ans. 2, 2, 2, 2, 5, 5, and 5.

11. Find the greatest common measure of 124, 200, and 350.
Ans. 2.
12. Find the greatest common measure of 325, 240, and 460.
Ans. 5.
13. Find the greatest common measure of 270, 800, and 960.
Ans. 10.

14. Find the least common multiple of 14, 25, 8, and 20.
Ans. 1400.
15. Find the least common multiple of 8, 36, 9, and 17.
Ans. 1224.
16. Find the common multiples of 15, 20, 32, and 75.
Ans. 2400, 4800, 7200, &c.
17. Find the common measures of 300, 400, 500, and 600.
Ans. 2, 4, 5, 10, 20, 25, 50, and 100.
18. Find the common multiples of 24, 36, 60, and 84.
Ans. 2520, 5040, 7560, &c.

19. Find the greatest common measure, and also the least common multiple, of 74 and 126.

Ans. Greatest com. meas. 2; least com. mult. 4662.

20. The junior class in a school consists of 132 students, and the senior of 99. How might each class be divided, so that the whole school should be disposed in equal sections?

Ans. Into sections of 3, 11, or 33.

21. For what sum of money could a carpenter hire journeymen for one month, at 15 dollars, 21 dollars, or 24 dollars each, allowing the whole sum to be thus expended?

Ans. 840 dollars, or 1680 dollars, &c.

22. What is the smallest sum of money for which I could purchase a number of plows at 14 dollars each, or a number of carts at 30 dollars each, or a number of wagons at 90 dollars each? *Ans.* 630 dollars.

23. A wine merchant has 111 gallons of Madeira, 185 gallons of Port, and 259 gallons of Malaga, with which he wishes to fill a number of casks, all containing the same number of gallons, and without mixing the different kinds of wine. What must be the contents of each cask? *Ans.* 37 gallons.

24. A has 413 dollars, B 531 dollars, and C 590 dollars; and they agree to purchase horses, at the same price per head, provided each man can thus invest all his money. How many horses could each man purchase?

Ans. A could purchase 7, B 9, and C 10.

25. An island is 200 miles in circumference, and three persons, A, B, and C, start together, and travel the same way around it. A goes 20 miles per day, B 25, and C 40 miles per day. In what time would they all come together again at the same point from which they started?

First find the number of days it would require each person to go around the island. *Ans.* 40 days.

CHAPTER IV.

PRELIMINARY DEFINITIONS AND PRINCIPLES — REDUCTION OF FRACTIONS.

FRACTIONS.

§ 87. A *Fraction* is an expression of *one* or *more* of the *equal parts* into which any quantity may be divided.

One *half* is *one* of the *two* equal parts,—One *third* is *one* of the *three* equal parts,—Two *thirds* are *two* of the *three* equal parts, and so on, *of any quantity.*

What is meant by *one fourth* of a quantity? By *three fourths* of a quantity? By *one fifth* of a quantity? By *four fifths?*

Any quantity consists of how many *halves* of that quantity? Of how many *thirds?* Of how many *fourths?* Of how many *tenths?*

Which is the greater part, *one half* or *one third* of a quantity? One fourth or one seventh? One ninth or one fifth? One tenth or one hundredth? One sixth or one sixtieth?

How many is *one half* of 2? One third of 3? Two thirds of 3? Three fourths of 4? One fifth of 5? Five sixths of 6? One seventh of 7? Three eighths of 8? Four ninths of 9?

If the 2 *halves* of any quantity were each divided into 2 equal parts, into how many equal parts would the *whole quantity be divided?* What would each of those parts be called? One *half* is how many *fourths?*

If the 3 *thirds* of any quantity were each divided into 2 equal parts, into how many equal parts would the whole quantity be divided? What would each of those parts be called? One *third* is how many *sixths?*

If the 4 *fourths* of any quantity were each divided into 3 equal parts, into how many equal parts would the whole quantity be divided? What would each of those parts be called? One *fourth* is how many *twelfths?*

Numerator and Denominator.

§ 88. A fraction is *denoted by two numbers,* one above the other, with a line between them. The upper number is called the *numerator;* and the lower, the *denominator.*

The *numerator* shows the number of *equal parts in the fraction;* the *denominator* shows the number of such parts in the *whole quantity* divided.

Thus $\frac{3}{4}$, *three fourths;* 3 is the *numerator,* and 4 the *denominator.*

In $\frac{2}{3}$, which is the numerator, and what does it show? Which the denominator, and what does it show? In $\frac{4}{7}$? In $\frac{3}{8}$? In $\frac{4}{9}$?

The numerator and the denominator are together called the *terms* of the fraction.

Proper and Improper Fractions.

§ 89. A *proper fraction* is one whose numerator is *less* than *its denominator;* and whose *value* is, consequently, *less* than a *unit* or *whole one.*

Thus $\frac{1}{2}$, $\frac{2}{3}$, $\frac{3}{8}$, are proper fractions.

§ 90. An *improper fraction* is one whose numerator is *equal to*, or *greater than*, its denominator; and whose value is, accordingly, equal to, or greater than, a unit or whole one.

Thus $\frac{3}{3}$ is an improper fraction,—equal to a whole one; and $\frac{5}{3}$ is an improper fraction,—equal to $1\frac{2}{3}$, *one* and *two thirds.*

$\frac{6}{3}$ is equal to how many whole ones? $\frac{9}{4}$ is equal to how many whole ones? $\frac{10}{5}$? $\frac{13}{6}$? $\frac{21}{7}$? $\frac{35}{8}$? $\frac{45}{9}$? $\frac{60}{10}$ $\frac{100}{11}$ $\frac{130}{12}$?

Fractions Express Division.

§ 91. Every *proper fraction* expresses *the part that its numerator is* of its denominator.

For example take the fraction $\frac{4}{9}$, *four ninths.*

Since 1 is *one ninth* of 9, 4 is *four ninths* of 9; that is, the fraction expresses *the part that its numerator* 4 is of its denominator 9.

2 is what part of 3? 4 is what part of 7? 5 is what part of 13?
9 is what part of 16? 11 is what part of 25? 17 is what part of 39?

§ 92. Every fraction, whether proper or improper, is equal to its *numerator divided by its denominator.*

For example, the fraction $\frac{4}{9}$ is the quotient of $4 \div 9$ (§ 47); being the same as $\frac{1}{9}$ of 4 (§ 51).

And the fraction $\frac{9}{4}$ is $9 \div 4$, equal to $\frac{1}{4}$ of 9, equal to $2\frac{1}{4}$ (§ 56).

$\frac{2}{3}$ is equal to what part of 2? $\frac{5}{6}$ is equal to what part of 5?
$\frac{3}{13}$ is equal to what part of 3? $\frac{23}{25}$ is equal to what part of 23?
$\frac{7}{30}$ is equal to what part of 7? $\frac{31}{45}$ is equal to what part of 31?

$\frac{4}{3}$ is how many units or whole ones? $\frac{9}{3}$ is how many units or whole ones?
$\frac{27}{4}$ is how many units or whole ones? $\frac{41}{9}$ is how many units or whole ones?
$\frac{64}{8}$ is how many units or whole ones? $\frac{39}{10}$ is how many units or whole ones?

Constant Value of a Fraction.

§ 93. The value of a fraction remains *the same* when its numerator and denominator are both multiplied, or both divided, by the *same number.*

Taking, for example, $\frac{3}{4}$, and multiplying both its terms by 2, we have $\frac{6}{8}$.

Now if any quantity were divided into 4 *fourths*, each *one* of these fourths, divided into *two equal parts*, would make 2 *eighths* of the quantity; then 3 *fourths* would make 6 *eighths;* that is, $\frac{3}{4}=\frac{3}{4}\times\frac{2}{2}=\frac{6}{8}$.

Prove that $\frac{3}{5}$ is equal to $\frac{6}{10}$. Prove that $\frac{2}{6}$ is equal to $\frac{6}{18}$.

The truth of this principle is also evident from regarding a fraction as a *quotient*, its numerator being a *dividend*, and its denominator the *divisor* (§ 92 and 57).

REDUCTION OF FRACTIONS.

§ 94. *Reduction*, in general, consists in changing the *form* or *expression* of a quantity, without *altering its value.*

Thus $\frac{2}{5}$ may be changed to the form $\frac{4}{10}$, $\frac{6}{15}$, &c., without altering its value (§ 93).

FRACTIONS REDUCED TO THEIR LOWEST TERMS.

§ 95. A fraction is *reduced to lower terms* when its numerator and denominator are diminished, without altering its value.

For example, $\frac{12}{16}$ reduced to *lower terms*, is $\frac{6}{8}$, found by dividing 12 and 16 by 2 (§ 93).

Reduce $\frac{6}{8}$ to lower terms. Reduce $\frac{16}{24}$ to lower terms.
Reduce $\frac{10}{20}$ to lower terms. Reduce $\frac{50}{100}$ to lower terms.

§ 96. A fraction is *reduced to its lowest terms* when its numerator and denominator are made the *smallest* that will express the value of the given fraction.

Thus $\frac{12}{16}$ reduced to its *lowest terms* is $\frac{3}{4}$.

What is $\frac{5}{10}$ in its lowest terms? What is $\frac{6}{12}$ in its lowest terms?
What is $\frac{6}{9}$ in its lowest terms? What is $\frac{16}{24}$ in its lowest terms?

When a fraction is in its lowest terms, its numerator and denominator will be *prime to each other* (§ 77).

RULE XVI.

§ 97. *To reduce a fraction to its* LOWEST TERMS.

1. Divide both terms of the fraction by any *common measure* greater than a unit, and the quotients by any common measure greater than a unit, and so on, until the quotients become *prime to each other*. The last quotients will be the lowest terms of the fraction. Or,

2. Divide both terms of the fraction by their *greatest common measure;* the quotients will be the lowest terms.

EXAMPLE.

To reduce $\frac{90}{120}$ to its lowest terms.

$$\begin{array}{r} 10\,)\,\underline{90} \\ 3\,)\,\underline{9} \\ 3 \end{array} \qquad \begin{array}{r} 10\,)\,\underline{120} \\ 3\,)\,\underline{12} \\ 4 \end{array} \qquad \frac{90}{120}=\frac{3}{4}.$$

Dividing 90 and 120 both by 10, and the quotients 9 and 12 both by 3, the quotients 3 and 4 are prime to each other, and we have the given fraction in its lowest terms equal to $\frac{3}{4}$ (§ 93).

Or, dividing 90 and 120 both by 30, which is their greatest common measure (§ 77), we at once have $\frac{90}{120}=\frac{3}{4}$.

The advantage of reducing a fraction to its lowest terms, is, that the *value* of the fraction is then more readily perceived.

Thus we more readily perceive the value of $\frac{3}{4}$ than of $\frac{90}{120}$.

EXERCISES.

1. Reduce $\frac{25}{75}$ and $\frac{216}{360}$ to their lowest terms. *Ans.* $\frac{1}{3}$ and $\frac{3}{5}$.
2. Reduce $\frac{30}{90}$ and $\frac{125}{150}$ to their lowest terms. *Ans.* $\frac{1}{3}$ and $\frac{5}{6}$.
3. Reduce $\frac{45}{50}$ and $\frac{270}{403}$ to their lowest terms. *Ans.* $\frac{9}{10}$ and $\frac{9}{13}$.
4. Reduce $\frac{55}{75}$ and $\frac{99}{225}$ to their lowest terms. *Ans.* $\frac{11}{15}$ and $\frac{11}{25}$.
5. Reduce $\frac{39}{84}$ and $\frac{180}{468}$ to their lowest terms. *Ans.* $\frac{13}{28}$ and $\frac{5}{13}$.

6. At 25 dollars per acre, what quantity of land could be purchased for 15 dollars? *Ans.* $\frac{3}{5}$ of an acre.

7. At 18 dollars per ton for hay, what quantity of hay could be bought for 10 dollars? *Ans.* $\frac{5}{9}$ of a ton.

8. Allowing 365 days to a year, what part of a year is included in 146 days? *Ans.* $\frac{2}{5}$ of a year.

9. There being 1760 yards in a mile what part of a mile is included in 1320 yards? *Ans.* $\frac{3}{4}$ of a mile.

10. If 133 dollars were equally divided among 152 men, what would be the portion of each man (§ 92)? *Ans.* $\frac{7}{8}$ of a dollar.

11. If a person saves out of his income 290 dollars in a year, at what rate does he save per day? *Ans.* $\frac{58}{73}$ of a dollar.

12. What quantity of ground must a man plow per day, in order to accomplish 63 acres in 72 days? *Ans.* $\frac{7}{8}$ of an acre.

13. A footman performed a journey of 500 miles in 15 days. At what rate did he walk per day? *Ans.* $33\frac{1}{3}$ miles.

14. A farmer bought a tract of land containing 400 acres, for 18100 dollars. What was the price per acre? *Ans.* $45\frac{1}{4}$ dollars.

15. A speculator purchased 1000 head of cattle at 16 dollars each, and sold the whole of them for 21875 dollars. How much did he gain per head? *Ans.* $5\frac{7}{8}$ dollars.

FRACTIONS REDUCED TO A COMMON DENOMINATOR.

§ 98. Two or more fractions are said to have a *common denominator*, when they have the *same number* for a denominator.

Thus $\frac{2}{7}$, $\frac{4}{7}$, and $\frac{6}{7}$, have a common denominator.

Give another example of fractions having a common denominator.

§ 99. Two or more fractions may often be reduced, *mentally*, to a common denominator, by multiplying, or dividing, *both terms* of one or more of them, so as to make the denominator *the same for each*.

For example, $\frac{1}{2}$ and $\frac{2}{3}$ are reduced to a common denominator, by multiplying both terms of $\frac{1}{2}$ by 3, and of $\frac{2}{3}$ by 2.

We thus find $\frac{1}{2}=\frac{1\times3}{2\times3}=\frac{3}{6}$; and $\frac{2}{3}=\frac{2\times2}{3\times2}=\frac{4}{6}$ (§ 93). The *equivalent* of $\frac{1}{2}$ is $\frac{3}{6}$; and the *equivalent* of $\frac{2}{3}$ is $\frac{4}{6}$.

Give the *equivalents* of $\frac{2}{3}$ and $\frac{3}{4}$ in fractions having a *common denominator*. Of $\frac{1}{2}$ and $\frac{3}{5}$. Of $\frac{3}{4}$ and $\frac{2}{5}$. Of $\frac{1}{2}$, $\frac{2}{3}$, and $\frac{3}{4}$. Of $\frac{1}{3}$, $\frac{2}{5}$ and $\frac{3}{10}$.

Least, Common Denominator.

§ 100. Two or more fractions are reduced to their *least common denominator*, when the common denominator found is the smallest by which the *equivalent* of each fraction can be expressed.

For example, $\frac{3}{4}$ and $\frac{5}{6}$, reduced to their least common denominator, are equal, respectively, to $\frac{9}{12}$ and $\frac{10}{12}$.

Give the equivalents of $\frac{3}{8}$ and $\frac{5}{6}$, by their least common denominator. Of $\frac{5}{8}$ and $\frac{3}{12}$. Of $\frac{1}{10}$ and $\frac{2}{15}$. Of $\frac{1}{2}$, $\frac{3}{4}$, and $\frac{5}{8}$. Of $\frac{1}{3}$, $\frac{5}{6}$ and $\frac{7}{12}$.

RULE XVII.

§ **101.** *To reduce two or more fractions to a* COMMON DENOMINATOR.

1. Multiply each numerator by all the denominators except its own, for the *new numerators;* and multiply all the denominators together for the *common denominator.*

2. *If the least common denominator be required,*—take the *least* COMMON MULTIPLE of the given denominators, for the common denominator. Divide this multiple by the denominator of each given fraction, and multiply the quotient by the numerator, for the *new numerators.*

EXAMPLES.

1. To reduce $\frac{2}{3}$, $\frac{5}{6}$, and $\frac{7}{8}$, to a common denominator.

For the new numerators, we have

$$2\times6\times8=96; \quad 5\times3\times8=120; \quad 7\times6\times3=126;$$

and for the common denominator, $3\times6\times8=144$.

The equivalents of the given fractions, are, then,

$\frac{96}{144}$, $\frac{120}{144}$, and $\frac{126}{144}$, respectively.

2. To reduce the same fractions $\frac{2}{3}$, $\frac{5}{6}$, and $\frac{7}{8}$, to their *least common denominator.*

The least *common multiple* of the denominators 3, 6, and 8, is 24 (§ 84). Then 24 is the common denominator required.

Dividing 24 by each given denominator, and multiplying the *quotients* by the given numerators, respectively, we have for the new numerators,

$$(24\div3)\times2=16; \quad (24\div6)\times5=20; \quad (24\div8)\times7=21.$$

The given fractions are, then, respectively equal to,

$\frac{16}{24}$, $\frac{20}{24}$, and $\frac{21}{24}$.

This method will not find the least common denominator, in all cases, unless each of the given fractions is in its *lowest terms.*

For instance, if, in the above example, we take $\frac{14}{16}$ instead of its equal, $\frac{7}{8}$, the least common multiple will be 48, which is not the least common denominator by which the equivalent of each fraction can be expressed.

☞ In finding a common denominator, as above, both terms of each given fraction are multiplied by the *same number*.

Thus $\frac{2}{3}$, in the first example, has both its terms multiplied by 6×8,—producing the new terms $\frac{96}{144}$.

In the second example, the numerator 2 is multiplied by 8,=24÷3, and this is the same number by which the denominator 3 is multiplied, to produce the common denominator 24.

Hence the values of the given fractions remain the same in reducing them to a common denominator (§ 93). ☜

EXERCISES.

1. Reduce $\frac{2}{3}$, $\frac{4}{5}$, and $\frac{3}{8}$ to a common denominator.
Ans. $\frac{80}{120}$, $\frac{96}{120}$, and $\frac{45}{120}$.

2. Reduce $\frac{5}{11}$, $\frac{9}{7}$, and $\frac{3}{2}$ to a common denominator.
Ans. $\frac{70}{154}$, $\frac{198}{154}$, and $\frac{231}{154}$.

3. Reduce $\frac{3}{5}$, $\frac{4}{9}$, and $\frac{8}{13}$ to a common denominator.
Ans. $\frac{351}{585}$, $\frac{260}{585}$, and $\frac{360}{585}$.

4. Reduce $\frac{5}{8}$, $\frac{6}{7}$, and $\frac{3}{12}$ to a common denominator.
Ans. $\frac{420}{672}$, $\frac{576}{672}$, and $\frac{168}{672}$.

5. Reduce $\frac{3}{4}$, $\frac{5}{6}$, and $\frac{7}{8}$ to the least common denominator.
Ans. $\frac{18}{24}$, $\frac{20}{24}$, and $\frac{21}{24}$.

6. Reduce $\frac{1}{2}$, $\frac{1}{4}$, and $\frac{5}{6}$ to the least common denominator.
Ans. $\frac{6}{12}$, $\frac{3}{12}$, and $\frac{10}{12}$.

7. Reduce $\frac{2}{3}$, $\frac{4}{9}$, and $\frac{7}{12}$ to the least common denominator.
Ans. $\frac{24}{36}$, $\frac{16}{36}$, and $\frac{21}{36}$.

8. Reduce $\frac{4}{5}$, $\frac{5}{6}$, and $\frac{9}{10}$ to the least common denominator.
Ans. $\frac{24}{30}$, $\frac{25}{30}$, and $\frac{27}{30}$.

9. Reduce $\frac{4}{6}$, $\frac{2}{8}$, and $\frac{8}{12}$ to the least common denominator.
Ans. $\frac{16}{24}$, $\frac{6}{24}$, and $\frac{16}{24}$.

10. Reduce $\frac{2}{3}$, $\frac{6}{10}$, and $\frac{15}{20}$ to the least common denominator.
Ans. $\frac{40}{60}$, $\frac{36}{60}$, and $\frac{45}{60}$.

11. Reduce $\frac{3}{7}$, $\frac{4}{5}$, $\frac{5}{8}$, and $\frac{1}{9}$ to a common denominator.
Ans. $\frac{1080}{2520}$, $\frac{2016}{2520}$, $\frac{1575}{2520}$, $\frac{280}{2520}$.

12. Reduce $\frac{1}{2}$, $\frac{3}{4}$, $\frac{2}{9}$, and $\frac{1}{10}$ to a common denominator.
Ans. $\frac{360}{720}$, $\frac{540}{720}$, $\frac{160}{720}$, $\frac{72}{720}$.

13. Reduce $\frac{2}{5}$, $\frac{1}{8}$, $\frac{3}{7}$, and $\frac{4}{5}$ to a common denominator.
Ans. $\frac{560}{1400}$, $\frac{175}{1400}$, $\frac{600}{1400}$, $\frac{1120}{1400}$.

14. Reduce $\frac{1}{9}$, $\frac{2}{11}$, $\frac{3}{8}$, and $\frac{4}{7}$ to a common denominator.
Ans. $\frac{616}{5544}$, $\frac{1008}{5544}$, $\frac{2079}{5544}$, $\frac{3168}{5544}$.

15. Reduce $\frac{6}{11}$, $\frac{1}{3}$, $\frac{7}{13}$, and $\frac{1}{5}$ to a common denominator.
Ans. $\frac{1170}{2145}$, $\frac{715}{2145}$, $\frac{1155}{2145}$, $\frac{429}{2145}$.

One advantage of expressing Fractions by a *common denominator*, is, that we are thus enabled, most readily, to compare the *values* of fractions, in certain cases.

Comparison of Fractions.

§ 102. Fractions having different numerators and denominators, are most readily *compared with each other*, by reducing them to a common denominator, and then comparing the new *numerators.*

For example, we should not very readily perceive which is the greater fraction, $\frac{5}{7}$ or $\frac{8}{11}$. By reducing them to a common denominator, we have $\frac{55}{77}$ and $\frac{56}{77}$; from which we see at once that $\frac{8}{11}$ is $\frac{1}{77}$ the greater.

11. One person expends 5 dollars for coal, at 7 dollars per ton; and another, 6 dollars, at 9 dollars per ton. What quantity does each of them purchase, and which of them the greater quantity?

Ans. { The 1st $\frac{5}{7}$, the 2d $\frac{2}{3}$ of a ton;
The 1st the greater quantity.

12. A, B, and C, purchase iron;—A, at 37 dollars per ton; B, at 42; and C, at 50 dollars per ton. A lays out 20 dollars; B, 25; and C 30 dollars: what quantity of iron does each of them purchase,—which of them the largest, and which the smallest quantity?

Ans. { A, $\frac{20}{37}$, B, $\frac{25}{42}$, and C, $\frac{3}{5}$ of a ton;
C the largest, and A the smallest quantity.

INTEGERS AND MIXED NUMBERS REDUCED TO IMPROPER FRACTIONS.

§ 103. An *integer*, or *integral* number, is any whole number, in opposition to a *fraction.*

Thus 1, 5, 10, &c., are *integers.*

§ 104. A mixed number is an integer, or whole number, with a fraction annexed to it.

Thus $5\frac{3}{4}$, $7\frac{1}{2}$, are *mixed* numbers.

What kind of quantity is $\frac{3}{7}$? $\frac{13}{4}$? 25? $37\frac{1}{2}$?

§ 105. An integer is reduced to the form of an *improper fraction*, by taking a *unit* for a *denominator.*

Thus 5 is $\frac{5}{1}$, 5 *ones;* 10 is $\frac{10}{1}$, 10 *ones;* &c.

Or, an integer may be reduced to an improper fraction having any *proposed denominator.*

Thus 5 is equal to $\frac{10}{2}$, or $\frac{15}{3}$, or $\frac{20}{4}$; and so on.

7 is equal to how many *halves ?* How many 4*ths ?* 8*ths ?*
9 is equal to how many *halves ?* How many 6*ths ?* 14*ths ?*
12 is equal to how many *halves ?* How many 10*ths ?* 18*ths ?*

§ 106. A *mixed* number may be readily reduced to an improper fraction whose denominator is *that of the fraction annexed*.

For example, 5 being equal to $\frac{15}{3}$, $5\frac{2}{3}=\frac{17}{3}$.

$2\frac{1}{2}$ is how many *halves?* $3\frac{1}{4}$ is how many *4ths?* $4\frac{2}{3}$ is how many *3rds?*
$5\frac{3}{5}$ is how many *5ths ?* $7\frac{2}{9}$ is how many *9ths?* $9\frac{5}{8}$ is how many *8ths?*
11 is how many *9ths ?* $12\frac{7}{10}$ is how many *10ths ?*

RULE XVIII.

§ 107. *To reduce an integer, or a mixed number, to an improper fraction.*

1. TO REDUCE AN INTEGER. Under the given integer, regarded as a *numerator*, place 1 for the denominator. Or multiply the integer by any proposed denominator; the product will be the numerator.

2. TO REDUCE A MIXED NUMBER. Multiply the integer contained in it, by the denominator annexed; and to the product *add the numerator*, for a numerator to be placed over said denominator.

EXAMPLES.

1. To reduce the integer 25 to *7ths*.

$$25\times7=175;\ \text{hence}\ 25=\frac{175}{7}.$$

2. To reduce the mixed number $25\frac{3}{7}$ to an improper fraction.

$$25\times7=175;\ \text{and}\ 175+3=178;\ \text{hence}\ 25\frac{3}{7}=\frac{178}{7}.$$

EXERCISES.

1. Reduce 13, 35, and 74, each to *3rds*. *Ans.* $\frac{39}{3}$, $\frac{105}{3}$, and $\frac{222}{3}$.
2. Reduce 29, 83, and 90, each to *4ths*. *Ans.* $\frac{116}{4}$, $\frac{332}{4}$, and $\frac{360}{4}$.
3. Reduce 71, 55, and 89, each to *7ths*. *Ans.* $\frac{497}{7}$, $\frac{385}{7}$, and $\frac{623}{7}$.
4. Reduce 19, 91, and 100, each to *10ths*. *Ans.* $\frac{190}{10}$, $\frac{910}{10}$, and $\frac{1000}{10}$.
5. Reduce $25\frac{1}{2}$ and $34\frac{1}{3}$ to improper fractions. *Ans.* $\frac{51}{2}$ and $\frac{103}{3}$.
6. Reduce $83\frac{1}{5}$ and $94\frac{1}{4}$ to improper fractions. *Ans.* $\frac{416}{5}$ and $\frac{377}{4}$.
7. Reduce $74\frac{1}{6}$ and $47\frac{1}{12}$ to improper fractions. *Ans.* $\frac{445}{6}$ and $\frac{565}{12}$.
8. Reduce $39\frac{1}{10}$ and $16\frac{3}{17}$ to improper fractions. *Ans.* $\frac{391}{10}$ and $\frac{275}{17}$.
9. Reduce $12\frac{2}{3}$ and $14\frac{1}{2}$ first to improper fractions, and then to a common denominator. *Ans.* $\frac{38}{3}$ and $\frac{29}{2}$; $\frac{76}{6}$ and $\frac{87}{6}$.
10. Reduce $25\frac{1}{2}$, $39\frac{1}{4}$, and $234\frac{3}{8}$ first to improper fractions, and then to their least common denominator.

Ans. $\frac{51}{2}$, $\frac{157}{4}$, and $\frac{1875}{8}$; $\frac{204}{8}$, $\frac{314}{8}$, and $\frac{1875}{8}$.

11. How many bushels of apples, at $\frac{1}{4}$ of a dollar per bushel, may be purchased for 13 dollars?

The number of bushels *that may be purchased, is equal to the number of* 4ths *of a dollar in* 13 dollars. *Ans.* 52 bushels.

12. What number of horses could be fed on 150 bushels of oats, giving $\frac{1}{5}$ of a bushel to each? *Ans.* 750 horses.

13. At the rate of $\frac{1}{2}$ of a dollar per day, how many laborers could be hired, one day, for $4\frac{1}{2}$ dollars? *Ans.* 9 laborers.

14. How many lots of ground, each to contain $\frac{1}{4}$ of an acre, could be made out of a field containing $129\frac{3}{4}$ acres? *Ans.* 519 lots.

15. Required how long a company of workmen would be employed in graduating $33\frac{2}{5}$ miles of road, at the rate of $\frac{1}{5}$ of a mile per month. *Ans.* 167 months.

16. Allowing a mechanic to earn 35 dollars in 2 months, or $\frac{1}{6}$ *of a year*, what sum ought he to earn in 3 years?

In 3 *years there are* 18 sixths *of a year. If he earn* 35 *dollars* in 1 sixth *of a year, he will earn* 18 times 35 *dollars in* 18 sixths *of a year, that is, in* 3 *years.* *Ans.* 630 dollars.

17. If a steamer run at the rate of 5 miles in $\frac{1}{4}$ of an hour, how far will she run in 13 hours? *Ans.* 260 miles.

18. If $\frac{1}{2}$ of a ton of hay brings 9 dollars, what should be paid for $34\frac{1}{2}$ tons of hay, at the same rate? *Ans.* 621 dollars.

19. Allowing $\frac{1}{4}$ of an acre of ground to produce 11 bushels of wheat, how many bushels would be raised from two fields, containing, respectively, 39 acres, and $41\frac{3}{4}$ acres? *Ans.* 3553 bushels.

IMPROPER FRACTIONS REDUCED TO INTEGERS OR MIXED NUMBERS.

Since 2 *halves*, or 3 *thirds*, or 4 *fourths*, and so on, make a *unit* or whole one, any improper fraction may readily be reduced to an integer, or a mixed number.

For example $\frac{12}{3}$ is equal to 4, and $\frac{14}{3}$ is equal to $4\frac{2}{3}$.

$\frac{12}{4}$ is how many units or whole ones? $\frac{15}{4}$ is how many units or whole ones? $\frac{25}{5}$ is how many units or whole ones? $\frac{45}{6}$ is how many units or whole ones? $\frac{72}{9}$ is how many units or whole ones? $\frac{13}{3}$ is how many units or whole ones? $\frac{21}{7}$ is how many units or whole ones? $\frac{17}{8}$ is how many units or whole ones? $\frac{47}{11}$ is how many units or whole ones? $\frac{100}{12}$ is how many units or whole ones?

The following Rule is the reverse of the preceding one.

RULE XIX.

§ **108.** *To reduce an improper fraction to an integer, or a mixed number.*

1. Divide the numerator by the denominator, placing the divisor, or denominator, under the remainder, if any, and annexing the fraction so formed to the quotient.

2. The fraction annexed to the quotient may often be reduced to lower terms.

EXAMPLE.

To reduce $\frac{140}{25}$ to an integer, or a mixed number.

$140 \div 25$, gives *quotient* 5, and *remainder* 15;

Hence $\frac{140}{25}=5\frac{15}{25}=5\frac{3}{5}$.

The fraction formed of the divisor and remainder, will be in its *lowest terms*, or not, according as the improper *fraction reduced*, is, or is not, in its lowest terms.

For, if the dividend and divisor have any *common measure*, the divisor and remainder will have the same common measure (§ 79).

EXERCISES.

1. Reduce $\frac{75}{25}$ to an integer, or a mixed number. *Ans.* 3.
2. Reduce $\frac{130}{10}$ to an integer, or a mixed number. *Ans.* 13.
3. Reduce $\frac{372}{13}$ to an integer, or a mixed number. *Ans.* $28\frac{8}{13}$.
4. Reduce $\frac{480}{48}$ to an integer, or a mixed number. *Ans.* 10.
5. Reduce $\frac{1384}{15}$ to an integer, or a mixed number. *Ans.* $92\frac{4}{15}$.
6. Reduce $\frac{2783}{125}$ to an integer, or a mixed number. *Ans.* $22\frac{33}{125}$.

7. How many dollars must be paid for 120 pounds of cheese, at $\frac{1}{8}$ of a dollar per pound?

The 120 pounds *will cost* $\frac{120}{8}$ *of a dollar.* *Ans.* 15 dollars.

8. How many dollars must be paid for 875 pounds of rice, at $\frac{1}{16}$ of a dollar per pound? *Ans.* $54\frac{11}{16}$ dollars.

9. If $\frac{1}{15}$ of a barrel of flour will serve a family for a week how many barrels would serve them 52 weeks? *Ans.* $3\frac{7}{15}$ barrels.

10. If a person walk at the rate of $\frac{1}{20}$ of a mile per minute how many miles would he walk in 245 minutes? *Ans.* $12\frac{1}{4}$ miles

11. How many dollars should be paid for 7 yards of linen, at $\frac{3}{4}$ of a dollar per yard?

The 7 yards *will cost* 7 times $\frac{3}{4}$ *of a dollar, which will be* $\frac{21}{4}$ *of a dollar.* *Ans.* $5\frac{1}{4}$ dollars.

12. How many dollars should be paid for 25 bushels of wheat, at $\frac{7}{8}$ of a dollar per bushel? *Ans.* $21\frac{7}{8}$ dollars.

13. How many dollars should be paid for 19 pounds of tobacco, at $\frac{9}{16}$ of a dollar per pound? *Ans.* $10\frac{11}{16}$ dollars.

14. If a laborer's wages be $\frac{4}{5}$ of a dollar per day, how many dollars will he earn in 237 days? *Ans.* $189\frac{3}{5}$ dollars.

15. If a farmer raise $\frac{9}{10}$ of a ton of hay per acre, how many tons of hay would he raise on 45 acres? *Ans.* $40\frac{1}{2}$ tons.

16. How many dollars should be paid for 9 barrels of flour, at $5\frac{1}{2}$ dollars per barrel?

$5\frac{1}{2}=\frac{11}{2}$; then 9 times 11 *halves* is $\frac{99}{2}$. *Ans.* $49\frac{1}{2}$ dollars.

17. How many dollars should be paid for 3 hundred weight of beef, at $4\frac{1}{4}$ dollars per hundred weight? *Ans.* $12\frac{3}{4}$ dollars.

18. If a stage coach run at the rate of $7\frac{1}{2}$ miles per hour, how many miles would it run in 13 hours? *Ans.* $97\frac{1}{2}$ miles.

19. A farmer had in oats 64 acres of ground, which produced $30\frac{3}{4}$ bushels per acre. What was the entire produce? *Ans.* 1968 bushels.

20. A grazier sold 75 head of fat cattle, at the rate of $35\frac{7}{8}$ dollars a head. What did he get for the whole number? *Ans.* $2690\frac{5}{8}$ dollars.

21. A merchant sold 37 yards of superfine cloth, at $11\frac{1}{4}$ dollars per yard. What did the whole amount to? *Ans.* $416\frac{1}{4}$ dollars.

22. A miller sold 100 barrels of flour, at $3\frac{3}{16}$ dollars per barrel. What did the whole amount to? *Ans.* $318\frac{3}{4}$ dollars.

23. If a ship sail at the rate of $125\frac{3}{4}$ miles per day, how far will she sail in 73 days? *Ans.* $9179\frac{3}{4}$ miles.

24. If one acre of ground produce $25\frac{1}{3}$ bushels of wheat, how many bushels would 150 acres produce at the same rate? *Ans.* 3800 bushels.

25. Allowing a person on a journey to travel at the rate of $40\frac{1}{4}$ miles per day, how far would he go in 31 days? *Ans.* $1247\frac{3}{4}$ miles.

26. Allowing 24 men to accomplish a certain work in $5\frac{1}{2}$ days, in how many days ought one man to accomplish the same work? *Ans.* 132 days.

27. Allowing a certain quantity of provisions to suffice 35 men for $13\frac{3}{4}$ days, how long ought the same quantity to suffice one man? *Ans.* $481\frac{1}{4}$ days.

EXERCISES ON CHAPTER IV.

1. Reduce $\frac{142}{378}$ and $\frac{230}{755}$ to their lowest terms. *Ans.* $\frac{71}{189}$ and $\frac{46}{151}$.

2. Reduce $\frac{345}{800}$ and $\frac{436}{940}$ to their lowest terms. *Ans.* $\frac{69}{160}$ and $\frac{109}{235}$.

3. Reduce $\frac{475}{670}$ and $\frac{738}{804}$ to their lowest terms. *Ans.* $\frac{95}{134}$ and $\frac{123}{134}$.

4. Reduce $\frac{284}{300}$ and $\frac{600}{845}$ to their lowest terms. *Ans.* $\frac{71}{75}$ and $\frac{120}{169}$.

5. Reduce $\frac{432}{868}$ and $\frac{820}{1000}$ to their lowest terms. *Ans.* $\frac{108}{217}$ and $\frac{41}{50}$.

6. Reduce $\frac{2}{3}$, $\frac{7}{8}$, and $\frac{13}{15}$ to a common denominator. *Ans.* $\frac{240}{360}$, $\frac{315}{360}$, and $\frac{312}{360}$.

7. Reduce $\frac{9}{11}$, $\frac{3}{14}$, and $\frac{17}{20}$ to a common denominator. *Ans.* $\frac{2520}{3080}$, $\frac{660}{3080}$, and $\frac{2618}{3080}$.

8. Reduce $\frac{4}{5}$, $\frac{5}{6}$, and $\frac{11}{12}$ to a common denominator. *Ans.* $\frac{288}{360}$, $\frac{300}{360}$, and $\frac{330}{360}$.

9. Reduce $\frac{3}{10}$, $\frac{5}{13}$, and $\frac{7}{15}$ to a common denominator. *Ans.* $\frac{585}{1950}$, $\frac{750}{1950}$, and $\frac{910}{1950}$.

10. Reduce $\frac{7}{11}$, $\frac{8}{17}$, and $\frac{9}{20}$ to a common denominator. *Ans.* $\frac{2380}{3740}$, $\frac{1760}{3740}$, and $\frac{1683}{3740}$.

11. Reduce $\frac{3}{16}$, $\frac{13}{20}$, and $\frac{25}{60}$ to the least common denominator. *Ans.* $\frac{45}{240}$, $\frac{156}{240}$, and $\frac{100}{240}$.

12. Reduce $\frac{4}{16}$, $\frac{5}{20}$, and $\frac{21}{45}$ to the least common denominator. *Ans.* $\frac{180}{720}$, $\frac{180}{720}$, and $\frac{336}{720}$.

13. Reduce $\frac{3}{20}$, $\frac{4}{16}$, and $\frac{11}{32}$ to the least common denominator. *Ans.* $\frac{24}{160}$, $\frac{40}{160}$, and $\frac{55}{160}$.

14. Reduce $\frac{1}{30}$, $\frac{7}{40}$, and $\frac{19}{100}$ to the least common denominator. *Ans.* $\frac{20}{600}$, $\frac{105}{600}$, and $\frac{114}{600}$.

15. Reduce 9, 13, $28\frac{4}{5}$, and $31\frac{3}{5}$, respectively to 5ths. *Ans.* $\frac{45}{5}$, $\frac{65}{5}$, $\frac{144}{5}$, and $\frac{158}{5}$.

16. Reduce 10, 23, $40\frac{3}{8}$, and $73\frac{5}{8}$, respectively to 8ths. *Ans.* $\frac{80}{8}$, $\frac{184}{8}$, $\frac{323}{8}$, and $\frac{589}{8}$.

17. Reduce $3\frac{1}{4}$, $5\frac{2}{3}$, $10\frac{2}{5}$, and $13\frac{1}{6}$, to improper fractions. *Ans.* $\frac{13}{4}$, $\frac{17}{3}$, $\frac{52}{5}$, and $\frac{79}{6}$.

18. Reduce $7\frac{3}{12}$, $9\frac{4}{15}$, $75\frac{7}{8}$, and $90\frac{1}{9}$ to improper fractions. *Ans.* $\frac{87}{12}$, $\frac{139}{15}$, $\frac{607}{8}$ and $\frac{811}{9}$.

19. Reduce $\frac{275}{5}$, $\frac{483}{10}$, $\frac{1750}{12}$, and $\frac{2365}{15}$ to integral or mixed numbers. *Ans.* 55, $48\frac{3}{10}$, $145\frac{5}{6}$, and $157\frac{2}{3}$.

20. Reduce $\frac{340}{13}$, $\frac{400}{12}$, $\frac{1860}{120}$, and $\frac{2930}{300}$ to integral or mixed numbers. *Ans.* $26\frac{2}{13}$, $33\frac{1}{3}$, $15\frac{1}{2}$, and $9\frac{23}{30}$.

21. A laid out 25 dollars for iron, at 40 dollars per ton, and B laid out 35 dollars for iron, at 45 dollars per ton. What quantity of the article did each of them purchase?

Ans. A $\frac{5}{8}$ and B $\frac{7}{9}$ of a ton.

22. A bought 9 yards of linsey for 12 dollars, and B bought 21 yards for 24 dollars. At what rate did each of them pay per yard? *Ans.* A $1\frac{1}{3}$ and B $1\frac{1}{7}$ dollar per yard.

23. If $\frac{1}{4}$ of an acre of land sell for 11 dollars, what should be received, at the same rate, for two farms, one containing 175, and the other $217\frac{3}{4}$ acres? *Ans.* 17281 dollars.

24. A farmer sold to A 37 bushels of wheat, to B 100 bushels, and to C 123 bushels, at $\frac{5}{8}$ of a dollar per bushel. What did the whole quantity sold amount to? *Ans.* $162\frac{1}{2}$ dollars.

25. A merchant bought 45 yards of Irish linen for 30 dollars, and sold the same for 35 dollars. At what price per yard was the linen bought and sold?

Ans. Bought at $\frac{2}{3}$ and sold at $\frac{7}{9}$ of a dollar.

26. If $\frac{1}{8}$ of a yard of cloth cost 2 dollars, what should be paid, at the same rate, for two pieces, each containing 13 yards, and a third one containing $9\frac{7}{8}$ yards? *Ans.* 574 dollars.

27. Bought of one person 45 sheep; of another 170; of another 63; of another 21; and of another 71; at an average of $\frac{3}{4}$ of a dollar a head. What did the whole amount to?

Ans. $277\frac{1}{2}$ dollars.

28. A sold to B 35 pounds of loaf sugar, at $\frac{3}{16}$ of a dollar a pound; to C 24 pounds of cheese, at $\frac{1}{12}$ of a dollar a pound; and to D 41 pounds of coffee, at $\frac{4}{25}$ of a dollar a pound. What did each of the articles amount to?

Ans. $6\frac{9}{16}$, 2, and $6\frac{14}{25}$ dollars.

29. Bought a lot of ground for $25, at the rate of $75 per acre. What was the quantity purchased? *Ans.* $\frac{1}{3}$ of an acre.

30. Two travelers having a journey of 1000 miles to perform, proceed as follows, namely, the first goes 25 days at the rate of 30 miles per day, and the second 20 days at the rate of 40 miles per day. What part of the journey has each accomplished? *Ans.* The first $\frac{3}{4}$, and the second $\frac{4}{5}$ of the journey.

31. A expended 75 dollars for steel at 87 dollars per ton, and B expended 87 dollars for steel at 93 dollars per ton. What quantity was purchased by each? and which of the two purchased the greater quantity?

Ans. A $\frac{25}{29}$, B $\frac{29}{31}$ of a ton; and B the greater quantity.

32. A merchant sold 4 yards of superfine cloth at $12\frac{1}{2}$ dollars per yard, 16 yards of silk at $2\frac{1}{4}$ dollars per yard, 13 yards of linen at $\frac{7}{8}$ of a dollar per yard, and 9 yards of calico at $\frac{1}{4}$ of a dollar per yard. What did each of the articles amount to?

Ans. 50, 36, $11\frac{3}{8}$, and $2\frac{1}{4}$ dollars.

CHAPTER V.

ADDITION, SUBTRACTION, MULTIPLICATION, AND DIVISION OF FRACTIONS.

ADDITION OF FRACTIONS.

§ **109.** ADDITION OF FRACTIONS consists in finding the sum of two or more fractions.

The sum of two or more fractions is found by means of a *common denominator.*

Thus the sum of $\frac{2}{7}$ and $\frac{3}{7}$, is $\frac{5}{7}$; just as the sum of 2 *cents* and 3 *cents* is 5 *cents.*

What is the sum of $\frac{4}{8}$ and $\frac{3}{8}$? Of $\frac{5}{9}$ and $\frac{2}{9}$? Of $\frac{4}{10}$ and $\frac{5}{10}$? Of $\frac{3}{11}$, $\frac{2}{11}$, and $\frac{4}{11}$? Of $\frac{5}{12}$, $\frac{2}{12}$, and $\frac{3}{12}$? Of $\frac{7}{20}$, $\frac{9}{20}$, and $\frac{3}{20}$?

How many *units* or whole ones are there in the sum of $\frac{3}{5}$ and $\frac{2}{5}$? In the sum of $\frac{1}{6}$, $\frac{2}{6}$, and $\frac{3}{6}$? In the sum of $\frac{6}{7}$, $\frac{5}{7}$, and $\frac{3}{7}$? In the sum of $\frac{3}{8}$, $\frac{5}{8}$, and $\frac{7}{8}$? In the sum of $\frac{4}{10}$, $\frac{8}{10}$, and $\frac{9}{10}$?

§ **110.** Two or more fractions may often be reduced, mentally, to a common denominator, (§ 99), and then added together.

Thus to add together $\frac{2}{3}$ and $\frac{3}{4}$, we say $\frac{2}{3}$ is equal to $\frac{8}{12}$, and $\frac{3}{4}$ is equal to $\frac{9}{12}$; then $\frac{8}{12}+\frac{9}{12}=\frac{17}{12}=1\frac{5}{12}$.

What is the sum of $\frac{1}{2}$ and $\frac{1}{3}$? Of $\frac{1}{2}$ and $\frac{3}{4}$? Of $\frac{3}{5}$ and $\frac{5}{10}$? Of $\frac{1}{3}$, $\frac{3}{4}$, and $\frac{5}{6}$? Of $\frac{2}{3}$, $\frac{5}{6}$, and $\frac{4}{9}$? Of $\frac{3}{8}$, $\frac{3}{4}$, and $\frac{9}{16}$?

RULE XX.

§ **111.** *To add two or more fractions together.*

1. If the fractions have not a *common denominator,* reduce them to a common denominator.

2. Add all the numerators together, and place the sum, as a numerator, over their common denominator.

3. *Mixed numbers* may be added under the form of *improper fractions;* or, the fractions contained in them may be added, separately, and their sum added to that of the integers.

EXAMPLES.

1. To add together, $\frac{3}{5}$, $\frac{4}{7}$, and $\frac{5}{8}$.

Reducing these fractions to a common denominator,

we have $\frac{3}{5} = \frac{168}{280}$

$\frac{4}{7} = \frac{160}{280}$

and $\frac{5}{8} = \frac{175}{280}$

Adding the new numerators together, we have

$168 + 160 + 175 = 503.$

Placing the sum 503 over the common denominator 280, we have $\frac{3}{5} + \frac{4}{7} + \frac{5}{8} = \frac{503}{280}$, which is equal to $1\frac{223}{280}$.

2. To add together 56, $15\frac{2}{3}$, $8\frac{3}{4}$, and $7\frac{5}{12}$.

Reducing the mixed numbers to improper fractions,

we have $15\frac{2}{3} = \frac{47}{3}$,

$8\frac{3}{4} = \frac{35}{4}$,

and $7\frac{5}{12} = \frac{89}{12}$,

Reducing these fractions to a common denominator,

we have, $\frac{188}{12}$, $\frac{105}{12}$, and $\frac{89}{12}$.

Then $15\frac{2}{3} + 8\frac{3}{4} + 7\frac{5}{12} = \frac{188}{12} + \frac{105}{12} + \frac{89}{12} = \frac{382}{12} = 31\frac{5}{6}$; and the integer 56 added to $31\frac{5}{6}$ makes the entire sum $87\frac{5}{6}$.

Otherwise. Adding together the fractions contained in the given mixed numbers, we shall find $\frac{2}{3} + \frac{3}{4} + \frac{5}{12} = 1\frac{10}{12} = 1\frac{5}{6}$.

Adding together all the integers, $56 + 15 + 8 + 7 = 86$; then the entire sum is $86 + 1\frac{5}{6} = 87\frac{5}{6}$, as before.

Note. In all subsequent exercises, improper fractions in the answers are to be reduced to integers or mixed numbers; and proper fractions, to their lowest terms.

EXERCISES.

1. Add together $\frac{3}{4}$, $\frac{5}{6}$, $\frac{2}{3}$, and $\frac{4}{9}$. *Ans.* $2\frac{25}{36}$.
2. Add together $\frac{5}{8}$, $\frac{3}{5}$, $\frac{7}{10}$, and $\frac{2}{12}$. *Ans.* $2\frac{11}{120}$.
3. Add together $\frac{3}{7}$, $\frac{4}{5}$, $\frac{9}{20}$, and $\frac{5}{18}$. *Ans.* $1\frac{241}{252}$.
4. Add together 25, 34, $\frac{1}{3}$, and $\frac{7}{24}$ *Ans.* $59\frac{5}{8}$.
5. Add together 13, $\frac{5}{13}$, 73, and $\frac{13}{5}$. *Ans.* $88\frac{64}{65}$.

6. Find the sum of $3\frac{1}{4}$, $5\frac{2}{3}$, $10\frac{1}{2}$, and $35\frac{3}{8}$. *Ans.* $54\frac{19}{24}$.
7. Find the sum of $7\frac{3}{4}$, $9\frac{1}{5}$, $25\frac{5}{8}$, and $19\frac{7}{12}$. *Ans.* $62\frac{19}{120}$
8. Find the sum of $18\frac{1}{2}$, $\frac{9}{16}$, $75\frac{7}{8}$, and $50\frac{1}{5}$. *Ans.* $145\frac{11}{80}$.
9. Find the sum of 100, $15\frac{5}{8}$, $3\frac{2}{3}$, and $37\frac{1}{2}$. *Ans.* 157.
10. Find the sum of $10\frac{3}{4}$, 49, $\frac{5}{24}$, and $83\frac{3}{4}$. *Ans.* $143\frac{17}{24}$.

11. What sum should be paid for a vest at $4\frac{3}{4}$ dollars, and a hat at $5\frac{7}{8}$ dollars? *Ans.* $10\frac{5}{8}$ dollars.

12. What sum should be paid for a cord of wood at $3\frac{1}{2}$ dollars, a barrel of flour at $5\frac{3}{4}$ dollars, and a shote at $2\frac{1}{3}$ dollars? *Ans.* $11\frac{7}{12}$ dollars.

13. Bought a quantity of corn for $15\frac{7}{8}$ dollars, a ton of hay for 13 dollars, and a lot of pork for $19\frac{3}{4}$ dollars. What did the whole amount to? *Ans.* $48\frac{5}{8}$ dollars.

14. Sold wheat for 275 dollars, oats for $37\frac{3}{8}$ dollars, and rye for $27\frac{3}{5}$ dollars. What did the whole amount to? *Ans.* $339\frac{39}{40}$ dollars.

15. A merchant's bill was as follows: for calico $\frac{3}{4}$ of a dollar, linen $3\frac{3}{5}$ dollars, silk $13\frac{3}{4}$ dollars, and for groceries $21\frac{1}{8}$ dollars. What was the amount of the bill? *Ans.* $39\frac{9}{40}$ dollars.

16. A farmer paid three laborers for a month's work as follows: to the first, $15\frac{1}{2}$ bushels of corn; to the second, $19\frac{1}{4}$ bushels; to the third, $23\frac{7}{8}$ bushels. How much corn did he pay them all? *Ans.* $58\frac{5}{8}$ bushels.

17. A manufacturer sold four pieces of cloth. The first piece contained $39\frac{2}{3}$ yards, the second $41\frac{5}{8}$ yards, the other two each $93\frac{1}{4}$ yards. How many yards did he sell? *Ans.* $267\frac{19}{24}$ yards.

18. A person on a journey traveled the first day 31 miles; the second and third, each $29\frac{3}{7}$ miles; the fourth and fifth, each $27\frac{5}{8}$ miles. How far did he go in the five days? *Ans.* $145\frac{3}{28}$ miles.

19. A stage coach ran for two hours at the rate of $8\frac{7}{10}$ miles per hour, and for two hours more at the rate of $7\frac{1}{9}$ miles per hour; how far was that in the whole time? *Ans.* $31\frac{28}{45}$ miles.

20. Sold to A, 25 barrels of apples, for $56\frac{1}{4}$ dollars; to B, $30\frac{1}{2}$ barrels, for 75 dollars; and to C, $10\frac{3}{4}$ barrels for $21\frac{7}{8}$ dollars. Required the quantity sold, and the sum received. *Ans.* $66\frac{1}{4}$ barrels: $153\frac{1}{8}$ dollars.

21. Bought of a grocer a sack of coffee, for $13\frac{5}{8}$ dollars; a barrel of sugar, for $18\frac{4}{10}$ dollars; and a keg of rice, for $5\frac{1}{16}$ dollars. What sum should be paid for the whole? *Ans.* $37\frac{7}{80}$ dollars.

22. Laid out for goods, at one time, $\frac{5}{7}$ of a dollar; at another time, $3\frac{2}{5}$ dollars; at another, $21\frac{1}{3}$ dollars; and at another, $9\frac{3}{4}$ dollars. What was the whole sum disbursed? *Ans.* $35\frac{83}{420}$ dollars.

23. A merchant sold to one person, 4 yards of cloth for 24 dollars; to another, $9\frac{3}{8}$ yards for $43\frac{3}{16}$ dollars; and to another, $13\frac{1}{8}$ yards for $40\frac{1}{5}$ dollars. Required the quantity of cloth sold, and the sum received. *Ans.* $26\frac{1}{2}$ yards: $107\frac{31}{80}$ dollars.

24. Bought in market a pound of butter for $18\frac{3}{4}$ cents, a

dozen eggs for 12½ cents, a quarter of veal for 56¼ cents, and a quart of peas for 6¼ cents. What did the whole amount to?
Ans. 93¾ cents.

25. Bought of a merchant a bunch of tape for 6¼ cents, a yard of cotton for 15 cents, a paper of pins for 31¼ cents, a yard of cambric for 25 cents, and a pair of gloves for 43¾ cents. What was the amount of the bill? *Ans.* 121¼ cents.

26. Bought of a farmer a quarter of beef for 8½ dollars, a cord of wood for 2¾ dollars, a ton of hay for 13 dollars, a quantity of corn for 18¼ dollars, and a lot of bacon for 15⅞ dollars. What did the whole amount to? *Ans.* 58⅜ dollars.

27. On a journey I traveled the first day 41½ miles, the second 40¾ miles, the third and fourth each 45 miles, the fifth and sixth each 39⅕ miles. What distance did I accomplish in the six days? *Ans.* 250$\frac{13}{20}$ miles.

28. Going out to collect money, I received from A 37½ *dollars*, from B 20 dollars more than from A, from C 5¾ dollars more than from B, and from D as much as from the other three together. What was the whole sum collected?
Ans. 316½ dollars.

29. A farmer bought at one time 97¼ acres of land, for 1000 dollars; at another, 127⅖ acres, for 1375½ dollars; at another, 500⅜ acres, for 6831 dollars; and at another, 333⅓ acres, for 4013$\frac{3}{16}$ dollars. What was the whole quantity of land that he purchased, and the sum that he paid for it?
Ans. 1058$\frac{43}{120}$ acres; 13219 $\frac{11}{16}$ dollars.

30. A contributed toward a charitable purpose, 23½ dollars, B contributed twice as much as A, C as much as B, D as much as A and B together, and E as much as all the rest. What was the whole contribution? *Ans.* 376 dollars.

31. An agriculturist sold to A, 135¾ bushels of corn, for 65½ dollars; and 20½ bushels of oats, for 5⅛ dollars. He also sold to B, 17⅜ bushels of oats, for 4¾ dollars; and 79 bushels of corn for 39 dollars. What quantity of each did he sell, and what sum did he receive for the whole?

Ans. 214¾ bushels of corn, and 37⅞ of oats: sum received 114⅜ dollars.

SUBTRACTION OF FRACTIONS.

§ 112. SUBTRACTION OF FRACTIONS consists in finding the *difference* between two fractions; that is, the *remainder* when the less is taken from the greater.

The difference between two fractions is found by means of *a common denominator.*

Thus the difference between $\frac{4}{9}$ and $\frac{7}{9}$ is $\frac{3}{9}$; just as the difference between 4 *dollars* and 7 *dollars* is 3 *dollars.*

What is the difference between $\frac{3}{10}$ and $\frac{8}{10}$? Between $\frac{5}{12}$ and $\frac{11}{12}$? Between $\frac{9}{13}$ and $\frac{3}{13}$? Between $\frac{11}{15}$ and $\frac{4}{15}$? Between $\frac{3}{17}$ and $\frac{13}{17}$?

§ 113. Two fractions may often be reduced, mentally, to a common denominator, (§ 99), and then subtracted, the one from the other.

Thus to subtract $\frac{2}{5}$ from $\frac{4}{7}$, we say $\frac{2}{5}$ is equal to $\frac{14}{35}$, and $\frac{4}{7}$ is equal to $\frac{20}{35}$; then $\frac{20}{35}-\frac{14}{35}=\frac{6}{35}$.

What is the difference between $\frac{2}{3}$ and $\frac{3}{4}$? Between $\frac{2}{5}$ and $\frac{2}{3}$? Between $\frac{5}{6}$ and $\frac{7}{12}$? Between $\frac{1}{2}$ and $\frac{1}{3}$? Between $\frac{4}{5}$ and $\frac{8}{15}$? Between $\frac{3}{4}$ and $\frac{5}{8}$? Between $\frac{5}{7}$ and $\frac{11}{14}$? Between $\frac{9}{10}$ and $\frac{9}{20}$?

§ 114. A *proper fraction* may be subtracted from an *integer*, by first subtracting the fraction from a *unit*, and then subtracting a unit from the integer.

Thus to subtract $\frac{3}{5}$ from 7, we say $\frac{3}{5}$ from 1 or $\frac{5}{5}$ leaves $\frac{2}{5}$, and 1 from 7 leaves 6; then $7-\frac{3}{5}=6\frac{2}{5}$.

Subtract $\frac{2}{3}$ from 13. $\frac{3}{4}$ from 17. $\frac{4}{5}$ from 20. $\frac{1}{6}$ from 18. $\frac{3}{7}$ from 20.

RULE XXI.

§ 115. *To subtract one fraction from another.*

1. If the fractions have not a *common denominator*, reduce them to a common denominator.

2. Subtract the less numerator from the greater, and place the remainder, as a numerator, over the common denominator.

3. *Mixed numbers* may be used in subtraction under the form of *improper fractions:* or, the fractions in them may be taken first in subtracting, and then the integers.

EXAMPLES.

1. To find the difference between $\frac{7}{12}$ and $\frac{8}{15}$.

Reducing these fractions to a common denominator,

we have $\frac{7}{12}=\frac{105}{180}$,

and $\frac{8}{15}=\frac{96}{180}$,

Subtracting the less numerator 96 from the greater 105, and placing the remainder 9 over the common denominator 180, we find $\frac{7}{12}-\frac{8}{15}=\frac{9}{180}=\frac{1}{20}$.

2. To subtract $15\frac{2}{3}$ from $37\frac{4}{5}$.

Reducing these mixed numbers to improper fractions,

we have $15\frac{2}{3}=\frac{47}{3}$,

and $37\frac{4}{5}=\frac{189}{5}$.

Reducing these improper fractions to a common denominator, we have $\frac{47}{3}=\frac{235}{15}$, and $\frac{189}{5}=\frac{567}{15}$;

then $37\frac{4}{5}-15\frac{2}{3}=\frac{567}{15}-\frac{235}{15}=\frac{332}{15}=22\frac{2}{15}$,

and $\frac{189}{5}=\frac{567}{15}$.

Otherwise. Taking the fractions $\frac{2}{3}$ and $\frac{4}{5}$, contained in the two mixed numbers, and reducing them to a common denominator, we shall find $15\frac{2}{3}=15\frac{10}{15}$,

and $37\frac{4}{5}=37\frac{12}{15}$.

Then subtracting $\frac{10}{15}$ from $\frac{12}{15}$, and 15 from 37

we have $37\frac{12}{15}-15\frac{10}{15}=22\frac{2}{15}$ as before.

3. To subtract $26\frac{3}{4}$ from $139\frac{2}{3}$.

Reducing the fractions contained in these two mixed numbers, to a common denominator,

$$\begin{array}{rr} \text{we shall find } 139\frac{2}{3}= & 139\frac{8}{12} \\ \text{and } 26\frac{3}{4}= & \underline{26\frac{9}{12}} \\ & 102\frac{11}{12} \end{array}$$

As $\frac{9}{12}$ cannot be subtracted from $\frac{8}{12}$, we add a *unit*, that is, $\frac{12}{12}$ to $\frac{8}{12}$, making $\frac{20}{12}$, and say $\frac{9}{12}$ from $\frac{20}{12}$ leaves $\frac{11}{12}$.

We then add 1 to the 6, and say 7 from 9 leaves 2, &c. (§ 34.)

4. To subtract $1843\frac{13}{15}$ from 2745.

$$\begin{array}{r} 2745(\frac{15}{15}) \\ \underline{1843\ \frac{13}{15}} \\ 901\ \frac{2}{15} \end{array}$$

Here we annex, mentally, $\frac{15}{15}$, equal to a *unit*, to the upper umber, and say $\frac{13}{15}$ from $\frac{15}{15}$ leaves $\frac{2}{15}$. Then adding 1 to the we say 4 from 5 leaves 1, &c. (§ 34).

EXERCISES.

1. Subtract $\frac{4}{9}$ from $\frac{7}{10}$, and $10\frac{3}{4}$ from $27\frac{6}{7}$. *Ans.* $\frac{23}{90}$ and $17\frac{3}{28}$.
2. Subtract $\frac{9}{10}$ from $\frac{12}{13}$, and $8\frac{1}{3}$ from $94\frac{4}{5}$. *Ans.* $\frac{3}{130}$ and $86\frac{7}{15}$.
3. Subtract $\frac{7}{12}$ from $\frac{11}{14}$, and $13\frac{7}{8}$ from $87\frac{2}{3}$. *Ans.* $\frac{17}{84}$ and $73\frac{19}{24}$.
4. Subtract $\frac{17}{20}$ from $\frac{44}{25}$, and $24\frac{4}{5}$ from $99\frac{1}{2}$. *Ans.* $\frac{91}{100}$ and $74\frac{7}{10}$.
5. Subtract $\frac{8}{30}$ from $\frac{39}{45}$, and $9\frac{5}{9}$ from $74\frac{3}{7}$. *Ans.* $\frac{3}{5}$ and $64\frac{55}{63}$.

6. Find the difference between 349 and $574\frac{3}{4}$. *Ans.* $225\frac{3}{4}$.
7. Find the difference between 730 and $625\frac{5}{8}$. *Ans.* $104\frac{3}{8}$.
8. Find the difference between 287 and $720\frac{3}{7}$. *Ans.* $433\frac{3}{7}$.
9. Find the difference between 934 and $373\frac{5}{9}$. *Ans.* $560\frac{4}{9}$.
10. Find the difference between 870 and $780\frac{7}{10}$. *Ans.* $89\frac{3}{10}$.

11. If flour were bought at $4\frac{1}{16}$ dollars per barrel, and sold at $5\frac{3}{8}$ dollars per barrel, what would be the gain per barrel? *Ans.* $1\frac{5}{16}$ dollars.

12. From a barrel of wine which contained $31\frac{1}{2}$ gallons, $13\frac{3}{4}$ gallons were drawn. What quantity remained in the barrel? *Ans.* $17\frac{3}{4}$ gallons.

13. A person who had to make a journey of 500 miles, has traveled $275\frac{5}{8}$ miles on his way. How far has he yet to go? *Ans.* $224\frac{3}{8}$ miles.

14. A farmer having 1000 acres of land, sells to one of his neighbors $479\frac{7}{16}$ acres. How many has he remaining? *Ans.* $520\frac{9}{16}$ acres.

15. A manufacturer who had on hand $700\frac{5}{8}$ yards of cloth has sold 534 yards of it. What quantity remains on hand? *Ans.* $166\frac{5}{8}$ yards.

16. A merchant bought a quantity of bacon for $15\frac{3}{8}$ dollars, and a quantity of pork for $23\frac{1}{2}$ dollars. He sold the whole for 48 dollars; what did he gain by the sale? *Ans.* $9\frac{1}{8}$ dollars.

17. Bought at one time $147\frac{2}{3}$ bushels of coal, and at another time $320\frac{1}{5}$ bushels. Having consumed 200 bushels, I desire to know what quantity is still on hand? *Ans.* $267\frac{13}{15}$ bushels.

18. A bought of B 75 yards of cloth; of which he sold to C $18\frac{3}{4}$ yards, and to D $20\frac{5}{8}$ yards. How many yards has he left? *Ans.* $35\frac{5}{8}$ yards.

19. A gentleman having 3000 dollars to divide among his three sons, gives $753\frac{1}{2}$ dollars to the first, 1284 dollars to the second, and the remainder to the third. What sum does the third receive? *Ans.* $962\frac{1}{2}$ dollars.

20. A merchant bought two pieces of cotton each containing $34\frac{3}{8}$ yards, of which he has sold $18\frac{3}{4}$ yards. How many yards has he left? *Ans.* 50 yards.

21. If I should collect from A 200 dollars, from B and C each $175\frac{1}{2}$ dollars, and then pay to D $56\frac{7}{8}$ dollars, and to E the remainder of the sum collected, how many dollars would E receive ? *Ans.* $494\frac{1}{8}$ dollars.

22. Bought of A 40 cords of wood for $81\frac{3}{4}$ dollars, of which I sold to B 20 cords for $45\frac{1}{4}$ dollars. If I sell the rest of the wood to C for $43\frac{3}{4}$ dollars, what sum will I gain ? *Ans.* $7\frac{1}{4}$ dollars.

23. If a quantity of cloth be purchased for $321\frac{1}{4}$ dollars, a quantity of silk for 137 dollars, and a quantity of linen for $93\frac{7}{8}$ dollars, what will be the gain or loss if the whole be sold for 600 dollars ? *Ans.* Gain $47\frac{7}{8}$ dollars.

24. A person having 100 dollars on hand, laid out $17\frac{1}{2}$ dollars for provisions, and paid taxes amounting to $21\frac{3}{4}$ dollars; what sum had he remaining ? *Ans.* $60\frac{3}{4}$ dollars.

25. From the sum of 1500 dollars which I deposited in bank, having drawn, at different times, 200 dollars, $137\frac{3}{4}$ dollars, $313\frac{1}{2}$ dollars, and $79\frac{3}{8}$ dollars ; what sum have I yet in bank ? *Ans.* $769\frac{3}{8}$ dollars.

26. Bought a quantity of iron for 95 dollars, and of coal for $81\frac{7}{8}$ dollars. The iron was sold for $115\frac{3}{4}$ dollars, and the coal for 100 dollars; what profit was made on both commodities ? *Ans.* $38\frac{7}{8}$ dollars.

27. Bought 350 acres of land for $4327\frac{1}{4}$ dollars. Having sold $137\frac{5}{8}$ acres for $1387\frac{1}{8}$ dollars, I desire to know how many acres remain, and for what sum the remainder should be sold to make a profit of 500 dollars on the whole ?

Ans. $212\frac{3}{8}$ acres : $3440\frac{1}{8}$ dollars.

28. A merchant bought one piece of cloth containing $53\frac{1}{2}$ yards, another containing $39\frac{3}{8}$ yards, and another containing 40 yards. Having sold 13 yards from the first piece, $24\frac{3}{4}$ from the second, and $19\frac{1}{8}$ from the third, the merchant wishes to know the whole number of yards he has remaining.

Ans. 76 yards.

29. A speculator bought 1000 acres of land for $1587\frac{3}{5}$ dollars, and 500 acres for $737\frac{7}{8}$ dollars. Having sold $945\frac{1}{2}$ acres for 2000 dollars, he wishes to know what quantity of land he has remaining, and for what sum he could afford to sell the remainder, so as to lose nothing on the whole.

Ans. $554\frac{1}{2}$ acres ; $325\frac{19}{40}$ dollars.

MULTIPLICATION OF FRACTIONS.

§ 116. *Multiplying by a fraction* consists in finding *such a part of the multiplicand* as is expressed by the multiplier.

For example, 12 *multiplied by* $\frac{5}{6}$ is 5 *times* $\frac{1}{6}$ of 12, which is $\frac{5}{6}$ of 12, equal to 10.

How many is $\frac{1}{2}$ of 6, or 6 *multiplied by* $\frac{1}{2}$? 6 multiplied by $\frac{1}{3}$?
How many is $\frac{1}{4}$ of 12, or 12 multiplied by $\frac{1}{4}$? $\frac{3}{4}$ of 12, or $12\times\frac{3}{4}$?

$\frac{1}{5}$ of 20, or $20\times\frac{1}{5}$? $\frac{4}{5}$ of 20, or $20\times\frac{4}{5}$? $\frac{5}{7}$ of 35, or $35\times\frac{5}{7}$?
$\frac{1}{6}$ of 30, or $30\times\frac{1}{6}$? $\frac{5}{6}$ of 30, or $30\times\frac{5}{6}$? $\frac{3}{8}$ of 40, or $40\times\frac{3}{8}$?

How many is 12 multiplied by $3\frac{1}{2}$; that is, 3 times 12, together with $\frac{1}{2}$ of 12? 8 multiplied by $4\frac{1}{4}$? $10\times6\frac{2}{5}$? $12\times5\frac{5}{7}$?

How many is 20 multiplied by $4\frac{1}{5}$: that is, 4 times 20, together with $\frac{1}{5}$ of 20? 24 multiplied by $3\frac{1}{6}$? $8\times9\frac{3}{4}$? $12\times10\frac{5}{6}$?

Compound Fractions.

§ 117. A fraction *multiplied by another fraction*, or divided by an *integer*, may be expressed as a *compound* fraction, that is, *a fraction of a fraction.*

Thus $\frac{5}{6}\times\frac{2}{3}$ is $\frac{2}{3}$ of $\frac{5}{6}$, (§ 116 ;) and $\frac{5}{6}\div4$ is $\frac{1}{4}$ of $\frac{5}{6}$, (§ 51).

The expressions $\frac{2}{3}$ of $\frac{5}{6}$, and $\frac{1}{4}$ of $\frac{5}{6}$ are called *compound fractions*, in contradistinction to *simple fractions*, which consist of a single numerator and denominator. Hence,

§ 118. Multiplying *two or more fractions* together is equivalent to reducing a *compound* to a *simple* fraction.

RULE XXII.

§ 119. *To multiply a fraction by a fraction.*

1. Multiply the numerators together for a numerator, and the denominators together for a denominator.

2. *An integer and a fraction are multiplied together*, by multiplying the numerator, or dividing the denominator, of the fraction, by the integer.

3. A *mixed number* may be used in multiplication under the form of an *improper fraction*; or the integer and fraction in it may be taken separately in multiplying,—observing to add together the separate products.

EXAMPLES.

1. To multiply $\frac{5}{7}$ by $\frac{3}{4}$; that is, to find $\frac{3}{4}$ of $\frac{5}{7}$.

$$\frac{5}{7}\times\frac{3}{4}=\frac{5\times3}{7\times4}=\frac{15}{28}.$$

2. To multiply $\frac{5}{24}$ by 6; that is to find 6 times $\frac{5}{24}$.

Multiplying the *numerator* by the *integer*,

$$\text{we have } \frac{5}{24}\times6=\frac{5\times6}{24}=\frac{30}{24}=1\frac{6}{24}=1\frac{1}{4}.$$

Or, *dividing the denominator* by the integer,

$$\text{we have } \frac{5}{24}\times6=\frac{5}{24\div6}=\frac{5}{4}=1\frac{1}{4}\text{; as before.}$$

3. To multiply $5\frac{2}{3}$ by $2\frac{1}{2}$; that is, to find *twice* $5\frac{2}{3}$, together with $\frac{1}{2}$ of $5\frac{2}{3}$.

Reducing the two mixed numbers to *improper fractions*,

we have $5\frac{2}{3}=\frac{17}{3}$, and $2\frac{1}{2}=\frac{5}{2}$.

Then $5\frac{2}{3}\times2\frac{1}{2}=\frac{17}{3}\times\frac{5}{2}=\frac{85}{6}=14\frac{1}{6}$.

Otherwise. Taking the integer and fraction in each mixed number, separately, we shall find $5\frac{2}{3}\times2=11\frac{1}{3}$.

and $\frac{1}{2}$ of $5\frac{2}{3}=2\frac{5}{6}$. Then $11\frac{1}{3}+2\frac{5}{6}=14\frac{1}{6}$. (§ 23).

In multiplying, we say *twice* $\frac{2}{3}$ is $\frac{4}{3}$, equal to $1\frac{1}{3}$. Setting down $\frac{1}{3}$, and *carrying* 1,—*twice* 5 is 10, and 1 is 11.

Next, $\frac{1}{2}$ of 5 is 2, with 1 over; this 1, equal to $\frac{3}{3}$, added to the $\frac{2}{3}$ makes $\frac{5}{3}$; then $\frac{1}{2}$ of $\frac{5}{3}$ is $\frac{5}{3}\times\frac{1}{2}=\frac{5}{6}$.

☞ Recurring to the first example, we remark, first, that $\frac{1}{4}$ of $\frac{1}{7}$ is $\frac{1}{28}$. For if any quantity were divided into 7 *sevenths*, and each one of these *sevenths* were divided into 4 *equal parts*, these last parts would be 28*ths* of the quantity, since 7 times 4=28.

That is, 1 *fourth* of 1 *seventh* is $\frac{1}{28}$. 1 *fourth* of 5 *sevenths* is, therefore, $\frac{5}{28}$; and 3 *fourths* of 5 *sevenths* is 3 times as much as 1 *fourth* of it, that is, 3 times $\frac{5}{28}$, which is $\frac{15}{28}$.

This demonstration discovers two principles, as involved in the Rule for multiplying a fraction by a fraction.

First. Multiplying the *denominator* of a fraction, finds *such a part* of the fraction as is expressed by the *reciprocal of the multiplier*; and, then, secondly, multiplying the *numerator* finds as many of such parts as are expressed by the multiplier.

Thus, multiplying the denominator of $\frac{5}{7}$ by 4, finds $\frac{5}{28}=\frac{1}{4}$ of $\frac{5}{7}$;

then, multiplying the numerator of $\frac{5}{28}$ by 3, finds $\frac{15}{28}=\frac{3}{4}$ of $\frac{5}{7}$.☜

From the preceding demonstration it follows that,

§ **120.** In fractional, as in integral, multiplication, the product remains *the same*, when the multiplicand and multiplier are taken, the one for the other. Thus $\frac{5}{7}$ of $\frac{3}{4}=\frac{3}{4}$ of $\frac{5}{7}$.

EXERCISES.

1. Multiply $\frac{5}{8}$ by $\frac{2}{3}$, and $\frac{7}{20}$ by 5. *Ans.* $\frac{5}{12}$ and $1\frac{3}{4}$.
2. Multiply $\frac{4}{9}$ by $\frac{3}{5}$, and $\frac{11}{30}$ by 10. *Ans.* $\frac{4}{15}$ and $3\frac{2}{3}$.
3. Multiply $\frac{6}{13}$ by $\frac{1}{2}$, and 13 by $\frac{1}{3}$. *Ans.* $\frac{3}{13}$ and $4\frac{1}{3}$.
4. Multiply $\frac{8}{11}$ by $\frac{3}{2}$, and 15 by $\frac{4}{5}$. *Ans.* $1\frac{1}{11}$ and 12.
5. Multiply $\frac{7}{12}$ by $\frac{5}{6}$, and 39 by $\frac{3}{7}$. *Ans.* $\frac{35}{72}$ and $16\frac{5}{7}$.

6. Multiply $8\frac{3}{4}$ by $\frac{1}{2}$, and $9\frac{2}{3}$ by 3. *Ans.* $4\frac{3}{8}$ and 29.
7. Multiply $10\frac{1}{2}$ by 5, and $12\frac{1}{4}$ by $\frac{2}{3}$. *Ans.* $52\frac{1}{2}$ and $8\frac{1}{6}$.
8. Multiply 15 by $3\frac{1}{4}$, and 20 by $4\frac{1}{2}$. *Ans.* $48\frac{3}{4}$ and 90.
9. Multiply $9\frac{3}{8}$ by $5\frac{3}{4}$, and $10\frac{2}{5}$ by $1\frac{7}{8}$. *Ans.* $53\frac{29}{32}$ and $19\frac{1}{2}$.
10. Multiply $25\frac{5}{6}$ by $4\frac{1}{4}$, and 30 by $9\frac{4}{5}$. *Ans.* $109\frac{19}{24}$ and 294.

11. What should be paid for $\frac{3}{4}$ of a yard of linen, at the rate of $\frac{7}{8}$ of a dollar per yard?

It is plain that $\frac{3}{4}$ of a yard will cost $\frac{3}{4}$ of $\frac{7}{8}$ of a dollar. $\frac{3}{4}$ of $\frac{7}{8}$, the same as $\frac{7}{8}\times\frac{3}{4}$, is a compound fraction, *to be reduced to a simple fraction.* (§ 118). *Ans.* $\frac{21}{32}$ of a dollar.

12. What should be paid for $\frac{2}{3}$ of a barrel of apples, if the whole barrel be worth $\frac{15}{16}$ of a dollar? *Ans.* $\frac{5}{8}$ of a dollar.

13. A person owning $\frac{7}{12}$ of a tract of land, sells $\frac{3}{5}$ of his share to A; what part of the whole tract does A purchase? *Ans.* $\frac{7}{20}$ of the whole.

14. What should be paid for $\frac{1}{2}$ of $\frac{7}{8}$ of a pound of tea, at the rate of $\frac{13}{16}$ of a dollar per pound? *Ans.* $\frac{91}{256}$ of a dollar.

15. A gentleman owning $\frac{1}{4}$ of a ship, sells $\frac{2}{7}$ of his share to A, and the rest of it to B. What part of the whole ship does he sell to each? *Ans.* To A $\frac{1}{14}$, and to B $\frac{5}{28}$ of the whole.

16. Bought $\frac{3}{5}$ of an acre of ground at the rate of $18\frac{3}{4}$ dollars per acre; required the sum to be paid for it. *Ans.* $11\frac{1}{4}$ dollars.

17. Sold $25\frac{1}{2}$ bushels of clover seed at $7\frac{1}{4}$ dollars per bushel, and 3 bushels at 7 dollars per bushel; what did the whole amount to? *Ans.* $205\frac{7}{8}$ dollars.

18. Find the entire cost of $\frac{3}{4}$ of a pound of pepper at $\frac{1}{4}$ of a dollar a pound, $\frac{3}{4}$ of a hundred weight of flour at $2\frac{1}{2}$ dollars a hundred, and $2\frac{1}{8}$ yards of cloth at 7 dollars a yard. *Ans.* $16\frac{15}{16}$ dollars.

19. Find the value of 3 pieces of cloth, each containing $25\frac{1}{4}$ yards, at $6\frac{3}{4}$ dollars per yard. *Ans.* $511\frac{5}{16}$ dollars.

20. Find the distance traveled by a person in $6\frac{1}{2}$ days, allowing him to proceed for 3 days at the rate of $30\frac{1}{3}$ miles per day, and the rest of the time at the rate of 27 miles per day.
Ans. $185\frac{1}{2}$ miles.

21. What would be the profit on 75 barrels of flour, purchased at $3\frac{3}{4}$ dollars a barrel, and sold at $4\frac{1}{2}$ dollars a barrel?
Ans. $56\frac{1}{4}$ dollars.

22. What would be the profit or loss on $35\frac{7}{8}$ yards of silk, purchased at $\frac{3}{4}$ of a dollar per yard, if $16\frac{1}{4}$ yards of it be sold at $1\frac{1}{4}$ dollars a yard, and the remainder at $\frac{5}{8}$ of a dollar a yard?
Ans. Profit $5\frac{43}{64}$ dollars.

23. A merchant bought $\frac{3}{4}$ of a load of pork, weighing 2460 pounds. He sold to A $\frac{2}{7}$ and to B $\frac{1}{3}$ of his purchase; how many pounds did A and B each obtain?
Ans. A $527\frac{1}{7}$, and B 615 pounds.

24. Having purchased 350 bushels of wheat at $\frac{7}{8}$ dollar a bushel, and sold $\frac{2}{3}$ of the quantity at 1 dollar a bushel, what would I gain or lose on the whole by selling the remainder at $\frac{3}{4}$ dollar a bushel? *Ans.* Gain $14\frac{7}{12}$ dollars.

25. In how many days ought one man to accomplish a work equivalent to what 12 men performed in $7\frac{1}{4}$ days?
Ans. 87 days.

26. In how many days ought one man to accomplish an undertaking which 17 men could perform in $13\frac{3}{8}$ days?
Ans. $227\frac{3}{8}$ days.

27. A farmer bought $\frac{4}{5}$ of a tract of land which contained $735\frac{1}{2}$ acres, and sold to his neighbor $\frac{1}{2}$ of his purchase. What part of the whole tract, and how many acres, did he sell?
Ans. $\frac{2}{5}$ of the tract; $294\frac{1}{5}$ acres.

28. Bought of A $3\frac{1}{2}$ cords of wood, at $2\frac{3}{4}$ dollars per cord; of B $7\frac{3}{8}$ cords, at $1\frac{5}{8}$ dollars per cord; and of C 10 cords, at $2\frac{1}{16}$ dollars per cord. What was the whole quantity of wood purchased, and the whole sum paid for it?
Ans. $20\frac{7}{8}$ cords; $41\frac{15}{64}$ dollars.

29. If 3 masons can build a wall of a certain length, height, and thickness, in $13\frac{1}{2}$ days, in what time ought one mason to build a wall of the same height and thickness, but $2\frac{1}{4}$ times as long? *Ans.* $91\frac{1}{8}$ days.

30. A speculator bought of A 189 acres of land at 10 dollars an acre, and of B $250\frac{1}{4}$ acres at 13 dollars an acre. He sold $\frac{2}{3}$ of the first tract at $18\frac{1}{2}$ dollars, and $\frac{2}{5}$ of the second at 19 dollars an acre; what would he make, on the whole, by selling the remainder of both tracts at 20 dollars an acre?
Ans. $3352\frac{13}{20}$ dollars.

DIVISION OF FRACTIONS.

§ 121. *Dividing by a fraction*, as well as by an integer, consists in finding *how many times* the dividend *contains the divisor*, or *what part* the dividend is of the divisor.

Thus $\frac{6}{7}$ divided by $\frac{2}{7}$ gives the quotient 3, because $\frac{6}{7}$ contains $\frac{2}{7}$ 3 *times;* and $\frac{1}{7}$ divided by $\frac{2}{7}$ gives the quotient $\frac{1}{2}$, because $\frac{1}{7}$ is $\frac{1}{2}$ of $\frac{2}{7}$.

How many times does $\frac{8}{9}$ contain $\frac{2}{9}$, or what is the quotient of $\frac{8}{9}$ divided by $\frac{2}{9}$? Of $\frac{6}{10}$ divided by $\frac{2}{10}$? Of $\frac{30}{41}$ divided by $\frac{6}{41}$?

What part is $\frac{1}{4}$ of $\frac{3}{4}$, or what is the quotient of $\frac{1}{4}$ divided by $\frac{3}{4}$? Of $\frac{1}{5}$ divided by $\frac{4}{5}$? Of $\frac{2}{6}$ divided by $\frac{3}{6}$? Of $\frac{3}{7}\div\frac{5}{7}$? Of $\frac{4}{3}\div\frac{10}{3}$?

§ 122. In fractional, as in integral, division, the dividend is a *product* given, and the divisor *one of its factors* given, to find the other factor.

Thus $\frac{8}{15}\div\frac{2}{3}$ is equal to $\frac{4}{5}$, because $\frac{8}{15}$ is the product of $\frac{2}{3}\times\frac{4}{5}$, that is, $\frac{8}{15}$ is $\frac{4}{5}$ of $\frac{2}{3}$; the quotient $\frac{4}{5}$ expressing the *part that the dividend* $\frac{8}{15}$ is of the divisor $\frac{2}{3}$.

What is the quotient of $\frac{9}{24}$ divided by $\frac{3}{4}$; that is, $\frac{3}{4}$ being one factor of $\frac{9}{24}$, what is the other factor? Of $\frac{18}{50}\div\frac{3}{10}$? Of $\frac{20}{36}\div\frac{5}{6}$? Of $\frac{32}{45}\div\frac{8}{9}$?

Reciprocal of a Fraction.

§ 123. The *reciprocal* of a fraction is the fraction *inverted;* and is equal to a *unit* divided by the fraction. (§ 50).

Thus the reciprocal of $\frac{2}{7}$ is $\frac{7}{2}$; equal to 1 or $\frac{7}{7}$ divided by $\frac{2}{7}$.

What is the reciprocal of $\frac{3}{4}$? Of $\frac{2}{5}$? Of $\frac{2}{13}$? Of $\frac{23}{39}$?

The reciprocal of a *mixed number* is that of its equivalent improper fraction. Thus the reciprocal of $5\frac{2}{3}=\frac{17}{3}$ is $\frac{3}{17}$.

What is the reciprocal of $2\frac{1}{2}$? Of $7\frac{3}{4}$? Of $10\frac{1}{4}$? Of $9\frac{3}{10}$?

Complex or Mixed Fractions.

§ 124. When the dividend or divisor is a *fraction* or a *mixed* number, the dividend placed over the divisor, with a line between, forms a *complex* or *mixed fraction.*

Thus, $\frac{3}{4}\div5$, $2\div3\frac{1}{2}$, may be expressed, respectively, by the *complex fractions* $\frac{\frac{3}{4}}{5}$, and $\frac{2}{3\frac{1}{2}}$.

These complex fractions may be read—*numerator* $\frac{3}{4}$, *denominator* 5; numerator 2, denominator $3\frac{1}{2}$.

A complex, as well as a simple, fraction is equal to its numerator divided by its denominator. (§ 92).

RULE XXIII.

§ 125. *To divide a fraction by a fraction.*

1. Divide the numerator of the dividend by that of the divisor, and the denominator by the denominator; or

2. Multiply the dividend by the *reciprocal of the divisor.*

3. *A fraction is divided by an integer,* by dividing the numerator by the integer, or multiplying the denominator by the integer.

4. *An integer is divided by a fraction,* by multiplying the integer by the reciprocal of the fraction.

5. A *mixed number* may be used in division under the form of an improper fraction. A mixed number may also be divided by an *integer,* by dividing the integer and fraction in the mixed number, separately.

EXAMPLES.

1. To divide $\frac{18}{20}$ by $\frac{2}{5}$.

Dividing numerator by numerator, and denominator by denominator,

we have $\frac{18}{20} \div \frac{2}{5} = \frac{18 \div 2}{20 \div 5} = \frac{9}{4} = 2\frac{1}{4}$.

2. To divide $\frac{9}{35}$ by $\frac{2}{3}$.

Here we cannot divide numerator by numerator, and denominator by denominator, without remainders. Multiplying, therefore, the dividend by the *reciprocal of the divisor,*

we have $\frac{9}{35} \div \frac{2}{3} = \frac{9}{35} \times \frac{3}{2} = \frac{27}{70}$.

3. To divide $\frac{10}{13}$ by 5.

Dividing the numerator of the fraction by the integer,

we have $\frac{10}{13} \div 5 = \frac{10 \div 5}{13} = \frac{2}{13}$.

Or, *multiplying* the *denominator* by the integer,

we have $\frac{10}{13} \div 5 = \frac{10}{13 \times 5} = \frac{10}{65} = \frac{2}{13}$, as before.

4. To divide 123 by $\frac{4}{5}$.

Multiplying the integer by the reciprocal of the fraction,

we have $123 \div \frac{4}{5} = 123 \times \frac{5}{4} = \frac{615}{4} = 153\frac{3}{4}$.

5. To divide $163\frac{2}{3}$ by 5.

Reducing the mixed number to an improper fraction,

we have $163\frac{2}{3} \div 5 = \frac{491}{3} \div 5 = \frac{491}{15} = 32\frac{11}{15}$.

Otherwise. Dividing the integer and fraction in the mixed number, separately,

$$\begin{array}{r} 5)\underline{1\,6\,3\,\frac{2}{3}} \\ 3\,2\,\frac{11}{15} \end{array}$$

We say 5 in 16, 3 times and 1 over; 5 in 13, *twice* and 3 over: this 3 and the $\frac{2}{3}$ make $3\frac{2}{3}$, equal to $\frac{11}{3}$; then $\frac{11}{3} \div 5$, that is, $\frac{1}{5}$ of $\frac{11}{3}$, is $\frac{11}{15}$.

☞ Dividing *a fraction by a fraction* is the *reverse* of *multiplying* a fraction by a fraction. (§122).

When the terms of the dividend cannot be divided by those of the divisor without a remainder, suppose each term of the former × by *both terms* of the latter; this will not *alter the value* of the dividend. (§93). Then the *resulting numerator* ÷ the numerator of the divisor, and the *denominator* by the denominator, gives, for the quotient, the *dividend* × the *reciprocal of the divisor.*

Thus, in the second example,

$$\tfrac{9}{35} = \frac{9 \times 2 \times 3}{35 \times 2 \times 3}; \text{ and } \frac{9 \times 2 \times 3}{35 \times 2 \times 3} \div \tfrac{2}{3} = \frac{9 \times 3}{35 \times 2} = \tfrac{9}{35} \times \tfrac{3}{2} = \text{the } \textit{quotient}. ☜$$

From the Rule, thus demonstrated, it follows that,

§ 126. In fractional, as in integral, division, the quotient is always such a part of the dividend as is expressed by the reciprocal of the divisor.

For the quotient is found by multiplying the dividend by said reciprocal; and multiplying by a fraction finds such a part of the multiplicand as is expressed by the multiplier.

EXERCISES.

1. Divide $\frac{18}{25}$ by $\frac{3}{5}$, and $\frac{21}{35}$ by 7. *Ans.* $1\frac{1}{5}$ and $\frac{3}{35}$.
2. Divide $\frac{13}{50}$ by $\frac{4}{9}$, and $\frac{8}{15}$ by 9. *Ans.* $\frac{117}{200}$ and $\frac{8}{135}$.
3. Divide $\frac{9}{14}$ by $\frac{10}{11}$, and 29 by $\frac{5}{7}$. *Ans.* $\frac{99}{140}$ and $40\frac{3}{5}$.
4. Divide $\frac{12}{17}$ by $\frac{4}{5}$, and $\frac{9}{75}$ by 13. *Ans.* $\frac{15}{17}$ and $\frac{3}{325}$.
5. Divide $\frac{35}{72}$ by $\frac{7}{9}$, and 95 by $\frac{7}{10}$. *Ans.* $\frac{5}{8}$ and $135\frac{5}{7}$.

6. Divide $8\frac{3}{4}$ by $5\frac{2}{3}$.

Reducing the mixed numbers to improper fractions,

we have $8\frac{3}{4} \div 5\frac{2}{3} = \frac{35}{4} \div \frac{17}{3} = \frac{35}{4} \times \frac{3}{17} = \frac{105}{68} = 1\frac{37}{68}$.

7. Divide $\frac{54}{75}$ by 9, and $10\frac{2}{3}$ by $3\frac{1}{4}$. *Ans.* $\frac{2}{25}$ and $3\frac{11}{39}$.
8. Divide 95 by $\frac{7}{12}$, and $125\frac{1}{2}$ by 7. *Ans.* $162\frac{6}{7}$ and $17\frac{13}{14}$.
9. Divide $\frac{27}{95}$ by 12, and 38 by $9\frac{4}{5}$. *Ans.* $\frac{9}{380}$ and $3\frac{43}{49}$.
10. Divide 100 by $\frac{4}{5}$, and $15\frac{2}{3}$ by $6\frac{1}{2}$. *Ans.* 125 and $2\frac{16}{39}$.
11. Divide $\frac{36}{53}$ by 3, and $340\frac{3}{8}$ by 8. *Ans.* $\frac{12}{53}$ and $42\frac{35}{64}$.
12. Divide 236 by $\frac{5}{8}$, and 425 by $7\frac{3}{7}$. *Ans.* $377\frac{3}{5}$ and $57\frac{11}{52}$.
13. Divide $\frac{4}{95}$ by $\frac{7}{10}$, and $18\frac{3}{4}$ by $10\frac{2}{5}$. *Ans.* $\frac{8}{133}$ and $1\frac{167}{208}$.
14. Divide 370 by $\frac{3}{11}$, and $213\frac{1}{4}$ by 11. *Ans.* $1356\frac{2}{3}$ and $19\frac{17}{44}$.
15. Divide $\frac{21}{100}$ by 21, and 11 by $213\frac{1}{4}$. *Ans.* $\frac{1}{100}$ and $\frac{44}{853}$.

16. How many yards of calico, at $\frac{1}{4}$ of a dollar per yard, may be purchased for $\frac{7}{8}$ of a dollar?

The number of yards will be the number of times $\frac{1}{4}$ of a dollar *is contained in* $\frac{7}{8}$ of a dollar, *that is,* $\frac{7}{8} \div \frac{1}{4}$. *Ans.* $3\frac{1}{2}$ yards.

17. How many weeks will a family be in consuming $19\frac{4}{5}$ barrels of flour, at the rate of $\frac{3}{4}$ of a barrel per week? *Ans.* $26\frac{2}{5}$ weeks.

18. How many days would a person be in traveling $175\frac{1}{2}$ miles, at the rate of $31\frac{3}{4}$ miles per day? *Ans.* $5\frac{67}{127}$ days.

19. A gentleman purchased a farm for $4379\frac{1}{16}$ dollars, paying $16\frac{7}{8}$ dollars per acre. Required the number of acres purchased. *Ans.* $259\frac{1}{2}$ acres.

20. A merchant laid out for broadcloth 5727 dollars, paying $5\frac{3}{4}$ dollars a yard. Required the number of yards purchased. *Ans.* 996 yards.

21. How many barrels of wine are there in 2753 gallons, allowing $31\frac{1}{2}$ gallons to make one barrel? *Ans.* $87\frac{25}{63}$ barrels.

22. How many years would there be in $5783\frac{1}{2}$ days, allowing $365\frac{1}{4}$ days to make one year? *Ans.* $15\frac{1219}{1461}$ years.

23. What quantity of salt may be purchased for $\frac{1}{4}$ of a dollar, at $\frac{5}{8}$ of a dollar per bushel?

$\frac{1}{4}$ *of a dollar will buy the same part of a bushel that* $\frac{1}{4}$ *of a dollar is of* $\frac{5}{8}$ *of a dollar; that is,* $\frac{1}{4} \div \frac{5}{8}$. *Ans.* $\frac{2}{5}$ of a bushel.

24. What quantity of iron may be purchased for $22\frac{1}{2}$ dollars, at the rate of 45 dollars per ton? *Ans.* $\frac{1}{2}$ of a ton.

25. What quantity of land may be purchased for $15\frac{3}{4}$ dollars, at the rate of 29 dollars per acre? *Ans.* $\frac{63}{116}$ of an acre.

26. If a person could accomplish a certain work in $25\frac{1}{2}$ days, what part of the work could he perform in $9\frac{1}{4}$ days? *Ans.* $\frac{37}{102}$ of the work.

27. A laborer agreed to work 30 days for a certain sum of money; having worked but $17\frac{1}{2}$ days, what part of the stipulated sum ought he to receive? *Ans.* $\frac{7}{12}$ of it.

28. A mason having undertaken to build a wall of a specified length, height, and thickness in 100 days, it is required to determine what part of it he ought to finish in $39\frac{1}{2}$ days. *Ans.* $\frac{79}{200}$ of it.

29. If $\frac{2}{3}$ of a yard of cloth cost 5 dollars, what is the price of a yard of the cloth at the same rate?

2 thirds of a yard being worth 5 dollars, 1 third of a yard is worth $\frac{1}{2}$ of 5 dollars; hence a *whole yard,* or 3 *thirds* of a yard, *is worth $\frac{3}{2}$ of 5 dollars; that is,* $5\times\frac{3}{2}$, or $5\div\frac{2}{3}$.

We may also reason thus: *the price of a yard will be such that $\frac{2}{3}$ of the price will be 5 dollars;* or the *price* $\times\ \frac{2}{3}=5$ dollars.

Hence 5 is a *dividend* or product *given,* $\frac{2}{3}$ a *divisor* or one factor *given, to find the quotient, which will be the other factor.* *Ans.* $7\frac{1}{2}$ dollars.

30. If $\frac{3}{4}$ of a ton of hay sell for 10 dollars, what should be paid for a ton of hay at the same rate? *Ans.* $13\frac{1}{3}$ dollars.

31. If $\frac{5}{8}$ of an acre of ground bring $21\frac{1}{4}$ dollars, what should be given for an acre at that rate? *Ans.* 34 dollars.

32. Allowing $\frac{4}{5}$ of a ton of coal to amount to $5\frac{3}{8}$ dollars, what is the value of a ton at that rate? *Ans.* $6\frac{23}{32}$ dollars.

33. Allowing $\frac{7}{10}$ of an acre of ground to produce $19\frac{1}{2}$ bushels of wheat, what would one acre produce at the same rate? *Ans.* $27\frac{6}{7}$ bushels.

34. What should be paid for 4 yards of cloth, when $\frac{3}{4}$ of a yard costs $6\frac{1}{2}$ dollars?

First find what should be paid for one yard. *Ans.* $34\frac{2}{3}$ dollars.

35. What should be paid for 7 gallons of wine, when $\frac{1}{2}$ of a gallon costs 1 dollar? *Ans.* 14 dollars.

36. What should be paid for 10 acres of ground, when $\frac{3}{4}$ of an acre sells for 28 dollars? *Ans.* $373\frac{1}{3}$ dollars.

37. What should be paid for 12 yards of silk, when $\frac{7}{8}$ of a yard sells for $1\frac{1}{4}$ dollars? *Ans.* $17\frac{1}{7}$ dollars.

38. What should be paid for $9\frac{1}{2}$ barrels of flour, when $\frac{1}{2}$ of a barrel sells for $3\frac{3}{4}$ dollars? *Ans.* $71\frac{1}{4}$ dollars.

39. Allowing $\frac{3}{8}$ of an acre of land to be worth $15\frac{7}{8}$ dollars, what should be given for $120\frac{1}{2}$ acres at the same rate? *Ans.* $5101\frac{1}{6}$ dollars.

40. Allowing $\frac{9}{10}$ of a ton of steel to amount to $100\frac{1}{2}$ dollars, what would $3\frac{4}{5}$ tons amount to at the same rate? *Ans.* $424\frac{1}{3}$ dollars.

42. If $5\frac{1}{2}$ barrels of flour sell for 24 dollars, what is the price of one barrel at the same rate?

$5\frac{1}{2}=\frac{11}{2}$; 11 *halves* cost 24 dollars; 1 *half* will cost $\frac{1}{11}$ of 24 dollars; *one barrel*, or 2 *halves*, will cost $\frac{2}{11}$ of 24 dollars; that is, $24\times\frac{2}{11}$, *or the part of* 24 *expressed by the* reciprocal *of* $5\frac{1}{2}$.
Ans. $4\frac{4}{11}$ dollars.

43. If a man travels $27\frac{3}{5}$ miles in $\frac{3}{4}$ of a day, at what rate does he travel per day? *Ans.* $36\frac{4}{5}$ miles.

44. If a ship sails $575\frac{1}{2}$ miles in $6\frac{3}{4}$ days, what is the average distance that she sails in one day? *Ans.* $85\frac{7}{27}$ miles.

45. What is the price of silk per yard, when $3\frac{1}{2}$ yards cost $4\frac{3}{8}$ dollars? What would 7 yards cost?
Ans. $1\frac{1}{4}$ dollar; and $8\frac{3}{4}$ dollars.

46. What is the price of coal per ton, when $\frac{3}{5}$ of a ton costs $9\frac{3}{4}$ dollars? What would $10\frac{1}{4}$ tons cost?
Ans. $16\frac{1}{4}$ dollars; and $166\ \frac{9}{16}$ dollars.

47. What is the price of land per acre, when 13 acres cost $71\frac{1}{2}$ dollars? What would $\frac{9}{10}$ of an acre cost?
Ans. $5\frac{1}{2}$ dollars; and $4\frac{19}{20}$ dollars.

48. If 25 cords of wood sell for $68\frac{3}{4}$ dollars, what is the price per cord? What should be paid for $\frac{3}{4}$ of a cord?
Ans. $2\frac{3}{4}$ dollars; $2\frac{1}{16}$ dollars.

49. If a man walk $62\frac{1}{3}$ miles in $18\frac{1}{2}$ hours, at what rate does he walk per hour? How far could he go in 20 hours?
Ans. $3\frac{41}{111}$ miles; and $67\frac{43}{111}$ miles.

50. If a rail road car run 230 miles in $10\frac{1}{4}$ hours, what is its average run per hour? What distance ought it to run in 23 hours? *Ans.* $22\frac{18}{41}$ miles; and $516\frac{4}{41}$ miles.

51. If $2\frac{1}{2}$ hundred weight of sugar cost $17\frac{1}{2}$ dollars, what will 15 hundred weight cost at the same rate?

First find the cost of one hundred weight. *Ans.* 105 dollars.

52. If $9\frac{3}{4}$ tons of hay amount to 78 dollars, what would $7\frac{1}{2}$ tons amount to at the same rate? *Ans.* 60 dollars.

53. A farmer bought $3\frac{1}{2}$ tons of plaster for 14 dollars, and sold to his neighbor $1\frac{1}{4}$ tons of it, at the same price per ton. What did the part sold amount to? *Ans.* 5 dollars.

54. A sold to B 30 acres of land for $622\frac{1}{2}$ dollars; and B sold to C $12\frac{3}{4}$ acres of the same land at the same price per acre. What did C pay for the land he bought?
Ans. $264\frac{9}{16}$ dollars.

55. D bought of E $35\frac{1}{2}$ bushels of clover seed, for 142 dollars; and afterwards sold to F $\frac{1}{4}$ of his purchase, at a profit of $1\frac{1}{4}$ dollar per bushel. What did the part sold to F amount to? *Ans.* $46\frac{19}{32}$ dollars.

ADDITION, ETC., OF FRACTIONS.

EXERCISES ON CHAPTER V.

§ **127.** *Compound* and *complex fractions* are prepared for addition, subtraction, &c. by reducing them to *simple fractions*; such reduction being nothing more than the *multiplication* and *division* of fractions. (§ 118, and § 124).

1. Find the sum of $\frac{1}{2}$ of $\frac{3}{4}$, $\frac{2}{3}$ of $\frac{4}{5}$, and $\frac{1}{5}$ of $\frac{3}{10}$ of $\frac{1}{20}$. *Ans.* $\frac{1367}{1500}$.

2. Find the difference between $\frac{1}{4}$ of $\frac{5}{8}$, and $\frac{2}{3}$ of $\frac{5}{6}$ of $\frac{7}{12}$. *Ans.* $\frac{145}{864}$.

3. Find the product of $\frac{3}{5}$ of $\frac{5}{8}$ multiplied by $\frac{1}{3}$ of $\frac{3}{5}$ of $\frac{4}{9}$. *Ans.* $\frac{1}{30}$.

4. Find the quotient of $\frac{4}{5}$ of $\frac{3}{10}$ divided by $\frac{1}{2}$ of $\frac{1}{3}$ of $15\frac{2}{3}$. *Ans.* $\frac{108}{1175}$.

5. Multiply the sum of $\frac{2\frac{1}{2}}{5}$ and $\frac{7}{3\frac{1}{2}}$ by the sum of $2\frac{1}{4}$ and $\frac{3}{4}$. *Ans.* $7\frac{1}{2}$.

6. Divide the sum of $\frac{1\frac{1}{3}}{4}$ and $\frac{9}{12\frac{1}{2}}$ by the sum of $3\frac{1}{8}$ and $\frac{5}{16}$. *Ans.* $\frac{1264}{4125}$.

7. Find the value of the expression
$(\frac{2}{5}+\frac{3}{4}+5\frac{1}{2}-\frac{1}{2}$ of $\frac{3}{4})\times 4$. *Ans.* $25\frac{1}{10}$.

8. Find the value of the expression
$(10\frac{2}{5}-5\frac{3}{4}+2\frac{1}{3}-\frac{2}{3}$ of $\frac{5}{6})\times\frac{4}{5}$. *Ans.* $5\frac{32}{225}$.

9. Find the value of the expression
$(19\frac{4}{5}+\frac{7}{10}-15+\frac{1}{3}$ of $2\frac{1}{4})\times\frac{3}{5\frac{1}{2}}$ *Ans.* $3\frac{9}{22}$.

10. Find the value of the expression
$(254+\frac{2}{7}+\frac{3}{8}-\frac{4}{5}$ of $15)\div\frac{2\frac{1}{2}}{5}$. *Ans.* $485\frac{9}{28}$.

11. Find the value of the expression
$(\frac{5}{3\frac{1}{2}}+\frac{1}{2}$ of $\frac{2}{3}$ of $\frac{2}{5}$ of $20)\div\frac{3\frac{1}{4}}{6\frac{1}{2}}$. *Ans.* $8\frac{4}{21}$.

12. A and B together have $387\frac{5}{8}$ dollars, and B has $31\frac{1}{4}$ dollars more than A: what sum has each of them? (§ 63.)
Ans. A $178\frac{3}{16}$, and B $209\frac{7}{16}$ dollars.

13. Bought at one time 10 bushels of wheat, at another $12\frac{3}{4}$ bushels, and at another $25\frac{2}{3}$ bushels; at $1\frac{1}{4}$ dollar per bushel: what did the whole amount to? *Ans.* $60\frac{25}{48}$ dollars.

14. Having on hand $19\frac{4}{5}$ tons of iron, if I sell $10\frac{1}{4}$ tons of it at 45 dollars, and the remainder at 43 dollars per ton, what will the whole amount to? *Ans.* $871\frac{9}{10}$ dollars.

15. Paid 70 dollars for wood, at 2 dollars per cord; and afterwards sold $\frac{1}{4}$ of the quantity, at $3\frac{1}{4}$ dollars per cord. What did the wood sold amount to? *Ans.* $28\frac{7}{16}$ dollars.

16. Laid out $59\frac{15}{16}$ dollars for silk at $\frac{7}{8}$ of a dollar per yard, and sold $\frac{1}{2}$ of the quantity purchased, at a profit of $\frac{3}{8}$ of a dollar per yard. What did the part sold amount to?

Ans. $42\frac{13}{16}$ dollars.

17. If $\frac{3}{4}$ of a yard of broadcloth cost $4\frac{1}{2}$ dollars, what should be paid for $\frac{5}{8}$ of a yard at the same rate? *Ans.* $3\frac{3}{4}$ dollars.

18. If $3\frac{1}{4}$ hundred weight of hemp sell for $16\frac{1}{4}$ dollars, what sum should be paid for $10\frac{2}{3}$ hundred weight?

Ans. $53\frac{1}{3}$ dollars.

19. A bought of B $13\frac{1}{2}$ tons of hay at 9 dollars per ton, and of C $15\frac{2}{5}$ tons at $10\frac{1}{2}$ dollars per ton. A then sold to D 9 tons at 12 dollars, and the rest of his purchase to E at 13 dollars, per ton: what did he gain on the hay? *Ans.* $83\frac{1}{2}$ dollars.

20. If 5 barrels of flour will supply a company for 20 days, how many days would $7\frac{1}{2}$ barrels supply the company?

Ans. 30 days.

21. In how many days ought one man to accomplish a piece of work which 5 men could do in $33\frac{1}{2}$ days? In how many days ought 14 men to accomplish the same work?

Ans. $167\frac{1}{2}$ days; and $11\frac{27}{28}$ days.

22. How long ought 13 persons to subsist on a stock of provisions which would be sufficient for 10 persons $29\frac{1}{2}$ days?

Ans. $22\frac{9}{13}$ days.

23. A person bought 19 barrels of apples, at $2\frac{1}{4}$ dollars per barrel. Having sold $12\frac{1}{2}$ barrels of them at $2\frac{1}{2}$ dollars a barrel, at what price per barrel must he sell the remainder, to make a profit of $5\frac{3}{4}$ dollars on the whole? *Ans.* $2\frac{17}{26}$ dollars.

24. Bought at one time 320 acres of land, at $25\frac{1}{2}$ dollars an acre; and at another time 275 acres, at $31\frac{1}{4}$ dollars an acre. If $\frac{3}{7}$ of the whole quantity were sold at 20 dollars, and the remainder at 30 dollars an acre, what would be the gain or loss? *Ans.* Loss $1453\frac{3}{4}$ dollars.

25. If 3 men can plow $15\frac{1}{2}$ acres of ground in 4 days, how much ought 1 man to plow in one day? How much ought 5 men to plow in $7\frac{2}{5}$ days? *Ans.* $1\frac{7}{24}$ acres; and $47\frac{19}{24}$ acres.

26. A purchased of B 40 yards of cloth for 260 dollars. He then sold to C $\frac{3}{5}$ of his purchase at a profit of $\frac{3}{8}$ dollar per yard, and the remainder to D at a loss of $\frac{1}{8}$ dollar per yard. What did A gain or lose by these several transactions?

Ans. Gained 7 dollars.

CHAPTER VI.

DECIMAL FRACTIONS.—DECIMAL OR FEDERAL MONEY.

DECIMAL FRACTIONS.

§ **128.** A *Decimal Fraction* is one or more 10*ths*, or 100*ths*, or 1000ths, &c., of a quantity, expressed by its *numerator* only with a point prefixed;—its denominator being understood to be 1 with as many 0s annexed as there are *figures in the numerator.*

Thus .3 is $\frac{3}{10}$; the denominator being understood to be 1 with *one cipher* annexed, since there is one figure in the numerator.

But .03 is $\frac{3}{100}$; the denominator being understood to be 1 with *two* 0s annexed, because there are two figures in the numerator .03.

What is expressed by .4, 4 with a point prefixed? By .05, 5 with a 0 and point prefixed? By .006? By .0005? By .00001?

One *tenth* is how many *hundredths?* One hundredth is how many *thousandths?* One thousandth is how many *ten-thousandths?*

The simple term *decimal* is sometimes used to designate a decimal fraction.

§ **129.** A *vulgar fraction*, as distinguished from a *decimal*, is any fraction expressed by a numerator and denominator; as, $\frac{4}{5}$, $\frac{3}{7}$, $\frac{7}{10}$.

The term *fraction*, used alone, commonly denotes a *vulgar fraction.*

Notation of Decimals.

§ **130.** The first figure on the right of the *decimal point*, denotes *tenths;* the second, *hundredths;* the third, *thousandths;* and so on, to ten-thousandths, hundred-thousandths, millionths, ten-millionths, &c.

Thus in the decimal .1 2 3 4 5 6,

the 1 is 1 *tenth*, the 2 is 2 *hundredths*, the 3 is 3 thousandths, the 4 is 4 ten-thousandths, &c. But

§ **131.** The *first two* figures on the right of the decimal point will together denote *hundredths;* the *first three* will together denote *thousandths;* the first four, ten-thousandths, &c.

Thus in the decimal .12, the 1 being $\frac{1}{10}=\frac{10}{100}$, and the 2 being $\frac{2}{100}$, both together make 12 *hundredths*.

Again, in .123, the 12 is $\frac{12}{100}$, the 3 is $\frac{3}{1000}$, and the whole 123 *thousandths*.

This is in accordance with the fact that the denominator understood to a decimal, is 1 with as many 0s annexed as there are figures in the numerator, (§ 128).

Complex or Mixed Decimals.

§ 132. A *complex* or *mixed* decimal is a decimal fraction with a *vulgar fraction* annexed to it.

Thus .5½ is 5½ *tenths;* that is, 5 *tenths* and ½ of 1 *tenth*;$=\frac{5\frac{1}{2}}{10}$;

.25¾ is 25¾ *hundredths;* the same as $\frac{25\frac{3}{4}}{100}$.

The vulgar fraction annexed to a decimal, denotes its proper part of 1 *tenth*, or 1 *hundredth*, &c., according as it is annexed to *tenths*, or *hundredths*, &c.; and must not be reckoned as in a separate place of decimals.

Scale of Decimals.

§ 133. In decimals, as in integers, *ten* of any *lower order* make *one* of the next higher order; or *one* of a higher order makes *ten* of the next lower order.

Thus beginning at *thousandths*, for example, 10 thousandths make 1 *hundredth;* 10 hundredths make 1 *tenth;* 10 *tenths* make 1 *unit*.

That is, the system of numbering by *tens*, is carried from units *up* through tens, hundreds, &c., and from units *down* through *tenths*, *hundredths*, &c.

RULE XXIV.

§ 134. *To read a Decimal Fraction.*

Call the successive figures *tenths*, *hundredths*, *thousandths*, *ten thousandths*, &c., from the decimal point *toward the right;* then, disregarding 0s next the point, read the number as if it were an integer, and add the *decimal name* of the last figure.

EXAMPLES.

1. To read a decimal .03457.

Calling the figures *tenths*, *hundredths*, &c. toward the right we find the last figure 7 to be 7 *hundred thousandths*.

Hence the decimal is 3457 *hundred-thousandths*. (§ 131.)

2. To read the mixed number 305.004.

The 4 is 4 thousandths; the whole is read, *three hundred* and *five*, and *four thousandths.*

Note.—An ambiguity may sometimes arise in the enunciation of decimals and mixed decimal numbers.

For example, .305 is three hundred and five *thousandths;* and 300.005 is three hundred, and five *thousandths.*

But when read in this manner, the two are not sufficiently distinguished from each other. The ambiguity may be prevented by using the word *decimal* before the fraction; thus, .305, *decimal* 305 *thousandths;* 300.005, 300 and decimal 5 thousandths.

EXERCISES.

Read each of the following decimals and mixed numbers.

1. .34.
2. .037.
3. 4.309.
4. 38.63.
5. 58.704.
6. .3368.
7. 43.009.
8. 6.0007.
9. 8739.3.
10. 373.854.
11. 4.00006.
12. 3068.37.
13. 27.1007.
14. 39.3834.
15. 341.0101.
16. .37403.
17. 54386.7.
18. 509.703.
19. 72.3436.
20. .38007.
21. 943.479.
22. 83.4863.
23. 73.8400.
24. 8.3000.
25. 1.26835.
26. 8.73473.
27. 7638.67.
28. 83.748.
29. 7367.85.
30. 96.73867.

Ciphers Annexed or Prefixed to Decimals.

§ **135.** Ciphers *annexed* to a decimal fraction do not *alter the value* of the decimal.

Thus .3=.30=.300, &c., since $\frac{3}{10}=\frac{30}{100}=\frac{300}{1000}$, &c. (§ 93).

§ **136.** Each 0 between the decimal point and the first significant decimal figure, *diminishes the decimal to* $\frac{1}{10}$ of its value without the 0.

Thus .3 is 3 *tenths*, .03 is 3 *hundredths*, and .003 is 3 *thousandths;* $\frac{3}{100}$ is $\frac{1}{10}$ of $\frac{3}{10}$, and $\frac{3}{1000}$ is $\frac{1}{10}$ of $\frac{3}{100}$; (§ 119).

How may the *integer* 1 be made to denote 1 *tenth?* 1 *hundredth?* 1 *thousandth?* 1 ten-thousandth? 1 hundred-thousandth?

How may the integer 5 be made to denote 5 *hundredths?* 5 thousandths? 5 hundred-thousandths? 5 millionths?

RULE XXV.

§ 137. *To denote tenths, hundredths, &c., by decimal fractions.*

Prefix the decimal point to the numerator, interposing so many 0s, when necessary, next the point, that—the successive figures being called *tenths, hundredths, thousandths,* &c., toward the right,—the last figure shall have the same *decimal name* with the parts to be expressed.

EXAMPLE.

1. To denote 54 *ten-thousandths* by a decimal fraction.

.0054

Prefixing the decimal point to the numerator 54, and interposing two 0s next the point, we find that, when the several figures are called *tenths, hundredths,* &c., toward the right, the 4 is *ten-thousandths,*—which is the name of the parts to be expressed.

EXERCISES.

In the notation of both integers and decimals.

Write in figures the following numbers—observing that, in the verbal expression, the integral and fractional parts are separated by a *comma.*

1. Fifteen hundredths.
2. Nineteen thousandths.
3. Six ten-thousandths.
4. Twenty-four thousandths.
5. Five hundred thousandths.
6. Thirty-nine millionths.
7. One hundred thousandths.
8. Ten ten-millionths.
9. Forty-nine hundredths.
10. Seventeen ten-thous'dths.
11. Fifty-two thousandths.
12. Seventy-one hundredths.
13. Eight hundred thous'dths.
14. Ninety-one millionths.
15. One hundred thousandths.
16. Four thousand and nine, and five thousandths.
17. Twenty thousand and seven, and nineteen ten-thousandths.
18. Fifteen millions, and three hundred and two thous'dths.
19. Five hundred and four thousand, and nine ten-thous'dths.
20. Five millions two hundred and one thousand, and three tenths.
21. Seven hundred millions, and three hundred and nine thousandths.
22. Eighteen millions three hund. and seventy-six thousand and thirty, and twelve hundredths.

FEDERAL MONEY.

§ 138. FEDERAL MONEY, or money of the United States, is expressed in units according to the *decimal* scale of numeration, that is, numeration by *tens*.

The units of Federal money are,

Eagles, Dollars, Dimes, Cents, and Mills.

10 mills *m* make 1 cent, *ct.*
10 cents " 1 dime, *d.*
10 dimes, or 100 cts. " 1 dollar, $.
10 dollars " 1 eagle, *E.*

The character $ is prefixed to dollars; thus $5 is 5 dollars.

One *cent* is what part of a dollar?
One *mill* is what part of a cent?
One mill is what part of a dollar?

3 cents are what part of a $?
7 mills are what part of a cent?
9 mills are what part of a $?

§ 139. The only denominations of Federal Money in common use, are *dollars* and *cents*;—eagles being expressed in dollars; dimes, in cents; and smaller values in fractions of a cent.

Thus, instead of 5 *eagles*, 4 *dollars*, 3 *dimes*, 2 *cents*, and 5 *mills;* we would say 54 *dollars*, 32½ *cents*.

DECIMAL NOTATION OF FEDERAL MONEY

Cents being expressed only in numbers less than 100, and mills in numbers less than 10, we have the following

RULE XXVI.

§ 140. *For the decimal expression of Federal Money.*

Regarding dollars as *integers*, make cents and mills *decimals* of a dollar, by prefixing to them the decimal point,—observing to interpose a 0 next the point, when the number of cents is less than 10,—and two 0s next the point when only mills, or a fraction of a cent, are given.

EXAMPLES.

31 cents is $.31, 31 *hundredths* of a dollar;
6¼ cents is $.06¼, 6¼ *hundredths* of a dollar; (§132.)
5 mills is $.005, 5 *thousandths* of a dollar;
¾ of a cent is $.00¾, ¾ of 1 *hundredth* of a dollar;
7 *cts.* and 5 *m.* is $.075, 75 *thousandths* of a dollar.

It may be useful to observe here, conversely, that,

§ **141.** In a decimal fraction *of a dollar*, the first figure after the point denotes tenths of a dollar, or *tens* of cents; the second denotes *cents;* the first two together denote *cents;* the third, *mills;* the fourth. *tenths* of a mill, &c.

Thus $.5 is 5 *tenths* of a dollar, equal to 50 cents;
$.453 is 45 cents and 3 mills;
$.0625 is 6 cents, 2 mills, and 5 *tenths* of a mill.

DECIMALS REDUCED TO VULGAR FRACTIONS.

RULE XXVII.

§ **142.** *To reduce a decimal to a vulgar fraction.*

1. Remove the decimal point from the numerator, and underneath set the proper denominator. (§ 128).

2. The fraction thus formed may often be reduced to lower terms.

EXAMPLE.

To reduce .125 to a vulgar fraction.

$$.125=\frac{125}{1000}=\frac{1}{8}.$$

EXERCISES.

Reduce each of the following decimals of a dollar to a vulgar fraction of a dollar.

1.	$.5.	*Ans.* $\$\frac{1}{2}$.	7.	$.9375.	*Ans.* $\$\ \frac{15}{16}$.
2.	$.25.	*Ans.* $\$\frac{1}{4}$.	8.	$.5625.	*Ans.* $\$\ \frac{9}{16}$.
3.	$.75.	*Ans.* $\$\frac{3}{4}$.	9.	$.1875.	*Ans.* $\$\ \frac{3}{16}$.
4.	$.375.	*Ans.* $\$\frac{3}{8}$.	10.	$.0625.	*Ans.* $\$\ \frac{1}{16}$.
5.	$.625.	*Ans.* $\$\frac{5}{8}$.	11.	$.0025.	*Ans.* $\$\frac{1}{400}$.
6.	$.875.	*Ans.* $\$\frac{7}{8}$.	12.	$.0075.	*Ans.* $\$\frac{3}{400}$.

13. Express the value of $13,75 by an integer and a vulgar fraction. *Ans.* $\$\ 13\frac{3}{4}$

14. Express the value of $20.125 by an integer and a vulgar fraction. *Ans.* $\$\ 20\frac{1}{8}$

15. Express the value of $35.625 by an integer and a vulgar fraction. *Ans.* $\$\ 35\frac{5}{8}$

16. Express the value of $49.0625 by an integer and a vulgar fraction. *Ans.* $\$49\frac{1}{16}$

17. Express the value of $57.9375 by an integer and a vulgar fraction. *Ans.* $\$57\frac{15}{16}$.

VULGAR FRACTIONS REDUCED TO DECIMALS.

RULE XXVIII.

§ **143.** *To reduce a vulgar fraction to a decimal.*

1. Divide the denominator into the numerator, with as many 0s annexed to the latter as may be necessary to find an *exact quotient*, or the number of decimal figures required.

2. Point off in the right of the quotient as many decimal figures as there were 0s annexed to the numerator; observing to prefix 0s to the quotient, when necessary to make up the number.

EXAMPLE.

To reduce $\frac{3}{125}$ to a decimal fraction.

125)3000(24. Then $\frac{3}{125}=.024$.

Annexing three 0s to the numerator, and dividing 3000 by the denominator, we find the quotient 24.

Prefixing a 0 to the quotient, to make up three decimal figures, for the three 0s annexed to the numerator, we find $\frac{3}{125}=.024$.

☞ The fraction is equal to its numerator 3 divided by its denominator 125. (§ 92.)

Each 0 annexed to the numerator, *multiplies* the fraction by 10 (§ 119—2); but each decimal figure made in the quotient, *divides* the quotient by 10, since each quotient figure thus becomes $\frac{1}{10}$ of its former value.

Thus multiplying and dividing by the same number, we preserve a *constant value* to the fraction. (§ 93).☜

EXERCISES.

Reduce each of the following fractions of a dollar to a decimal of a dollar.

1. $\$\frac{1}{2}$.	*Ans.* \$.5.	6. $\$\frac{7}{8}$. . .	*Ans.* \$.875.
2. $\$\frac{1}{4}$.	*Ans.* \$.25.	7. $\$\frac{1}{16}$. . .	*Ans.* \$.0625.
3. $\$\frac{3}{4}$.	*Ans.* \$.75.	8. $\$\frac{3}{16}$. . .	*Ans.* \$.1875.
4. $\$\frac{3}{8}$.	*Ans.* \$.375.	9. $\$\frac{5}{16}$. . .	*Ans.* \$.3125
5. $\$\frac{5}{8}$.	*Ans.* \$.625.	10. $\$\frac{9}{16}$. . .	*Ans.* \$.5625.

11. Reduce $\$17\frac{1}{8}$ to a decimal expression. *Ans.* \$17.125.
12. Reduce $\$13\frac{7}{16}$ to a decimal expression. *Ans.* \$13.4375.
13. Reduce $\$25\frac{11}{16}$ to a decimal expression. *Ans.* \$25.6875.
14. Reduce $\$31\frac{13}{16}$ to a decimal expression. *Ans.* \$31.8125.
15. Reduce $\$40\frac{15}{16}$ to a decimal expression. *Ans.* \$40.9375.

A Complex Reduced to a Simple Decimal.

§ 144. In a *complex* decimal, instead of the vulgar fraction annexed, we may put its equivalent decimal, without the point prefixed to it.

Thus in $.6\frac{1}{25}$, the $\frac{1}{25}=.04$; then $.6\frac{1}{25}=.604$.

16. Reduce $.25\frac{1}{2}$ to a simple decimal. . . . *Ans.* .255.
17. Reduce $.31\frac{1}{4}$ to a simple decimal. . . . *Ans.* .3125.
18. Reduce $.18\frac{3}{4}$ to a simple decimal. . . . *Ans.* .1875.
19. Reduce $.23\frac{1}{8}$ to a simple decimal. . . . *Ans.* .23125.
20. Reduce $.90\frac{1}{16}$ to a simple decimal. . . . *Ans.* .900625.

Approximate Decimals.

§ 145. A decimal which expresses a *near*, but not the *exact*, value of a vulgar fraction, or other quantity, is an *approximate* decimal.

In reducing $\frac{1}{3}$, for example, to a decimal,—if we annex one 0 to the 1 and divide by the 3, we find $\frac{1}{3}=.3\frac{1}{3}$;

by annexing two 0s to the 1, we find $\frac{1}{3}=.33\frac{1}{3}$;

by annexing three 0s to the 1, we find $\frac{1}{3}=.333\frac{1}{3}$; and so on.

In the first of these mixed decimals, the $\frac{1}{3}$ annexed is $\frac{1}{3}$ of 1 *tenth*, equal to $\frac{1}{30}$; in the second, it is $\frac{1}{3}$ of 1 *hundredth*, equal to $\frac{1}{300}$; and in the third, it is $\frac{1}{3}$ of 1 *thousandth*, equal to $\frac{1}{3000}$.

By omitting these small values, $\frac{1}{30}$, $\frac{1}{300}$, $\frac{1}{3000}$, we have .3 for a near or *approximate* value of $\frac{1}{3}$, .33 for a *nearer* value, and .333 for a *still nearer* value of $\frac{1}{3}$.

The sign + is commonly affixed to an approximate decimal; thus $\frac{1}{3}=.33+$, 33 hundredths, *nearly*.

Instead of the sign +, we shall employ a *comma* ', after the manner of an *apostrophe*, to denote an *approximate decimal.*

Thus $\frac{1}{3}=.33'$, 33 hundredths, *nearly*.

The number of figures to which an *approximate decimal* need be carried, in any particular case, will depend on the value of the whole quantity of which the decimal expresses a part.

In a decimal of a dollar, for example, two figures will give the number of *cents*, which is near enough for ordinary purposes. When greater accuracy is required, the third figure may be found, which will give the number of *mills*.

21. Reduce $\$\frac{1}{3}$ to an approximate decimal. . . *Ans.* .333'.
22. Reduce $\$\frac{2}{7}$ to an approximate decimal. . . *Ans.* .285'.
23. Reduce $\$\frac{4}{9}$ to an approximate decimal. . . *Ans.* .444'.

ADDITION, SUBTRACTION, MULTIPLICATION AND DIVISION OF DECIMALS, AND FEDERAL MONEY.

§ 146. The objects of Addition, Subtraction, Multiplication and Division, are the same for every kind of quantity; and, having been defined for integers and vulgar fractions, the definitions need not be repeated.

§ 147. Addition, Subtraction, &c., of Federal Money, are brought under the Rules to be given for the same operations, respectively, on decimal fractions, by regarding dollars as *integers*, and making cents and mills *decimals* of a dollar.

§ 148. The principles of notation being the same for decimals and integers, (§ 133 and 137) the methods of adding, subtracting, &c., will be the same for decimals and integers.

ADDITION OF DECIMALS.

RULE XXIX.

§ 149. *For the addition of decimals.*

Set *tenths* under *tenths*, *hundredths* under *hundredths*, &c., and add as in integers; observing to make in the right of the *sum* as many decimal figures as will be equal to the greatest number of decimal figures in any one of the given numbers.

EXAMPLE.

To find the sum of .25+84.346+.73+275.937.

$$\begin{array}{r} .25 \\ 84.346 \\ .73 \\ 275.937 \\ \hline 361.263 \end{array}$$

The sum is 361 and 263 *thousandths.*

Having set tenths under tenths, hundredths under hundredths, &c.,—this order also causing *units* to fall under *units*, tens under tens, &c., when mixed numbers are to be added—we add up the several columns of figures as in integers; and make three decimal figures .263 in the sum, this being the greatest number of decimal figures in any one of the given numbers.

EXERCISES

1. Find the Sum, 215.5+23.56+32.32. *Ans.* 271.38.
2. Find the Sum, .273+913.4+37.62. *Ans.* 951.293.
3. Find the Sum, .035+346.1+873.4. *Ans.* 1219.535.
4. Find the Sum, .874+2.763+7.390. *Ans.* 11.027.
5. Find the Sum, 387+534.6+83.81. *Ans.* 1005.41.
6. Find the Sum, 2.25+.7373+.7849. *Ans.* 3.7722.
7. Find the Sum, 48.36+8370+.0051. *Ans.* 8418.3651.
8. Find the Sum, 8.773+974.6+2703. *Ans.* 3686.373.
9. Find the Sum, 74.03+3737+4301. *Ans.* 8112.03.
10. Find the Sum, .9346+203.7+.7376. *Ans.* 205.3722.

11. Find the sum of 100 dollars 72½ cents, 25 dollars 6¼ cents, 34 dollars 5 cents, and 119 dollars 48¾ cents.

```
$100.72½
  25.06¼
  34.05
 119.48¾
────────
$279.32½
```
279 *dollars* 32½ *cents.*

Having made each number of cents a *decimal* of a dollar, (§ 140) and placed *tenths* under *tenths*, &c., we first add up the fractions of a cent, namely, ¾, ¼ and ½, and find the sum to be 6/4=1½. We set down the ½, and carry the 1 to 8.

In the sum we point off two decimal figures for *cents*, or *hundredths* of a $; (§ 132.)

12. What sum should be paid for a hat, at 5 dollars 87½ cents; a vest, at 3 dollars 18¾ cents; and a pair of shoes, at 2 dollars 62½ cents? *Ans.* $11.68¾.

13. What should be paid for a quarter of beef, at $7; a barrel of flour, at 4 dollars 56¼ cents; a lot of groceries, at 13 dollars 37½ cents; and a lot of butter, at 2 dollars 6¼ cents? *Ans.* $27.00.

14. Find the sum that must be paid for a quire of paper, at 25 cents; a bottle of ink, at 12½ cents; a dozen books, at 1 dollar 18¾ cents; and a bunch of quills, at 37½ cents. *Ans.* $1.93¾.

15. Find the sum that should be paid for a set of chairs, at $18; a pair of tables, at 35 dollars 50 cents; a looking-glass, at 5 dollars 18¾ cents; and a bedstead, at 9 dollars 31¼ cents. *Ans.* $68.00.

16. Bought a cord of wood, for 2 dollars 50 cents; a ton of hay, for 12 dollars 68¾ cents; a barrel of apples, for 2 dollars 56¼ cents; and quarter of beef, for 5 dollars 75 cents; required the sum paid. *Ans.* $23.50.

17. Sold a barrel of sugar, for $15; a sack of coffee, for 13 dollars 5 cents; a keg of rice, for 5 dollars 43¼ cents; and a box of candles, for 9 dollars 8 cents; required the sum received.
Ans. $42.56¼.

18. A merchant's bill was as follows: for 3½ yards of cloth, $21; for 3 pair of stockings, 1 dollar 87½ cents; for a dozen skeins of silk, 75 cents; required the amount of the bill.
Ans. $23.62½.

19. A farmer sold produce as follows, namely: wheat, for $300; corn, for 97 dollars 93¼ cents; hay, for 56 dollars 12½ cents; and oats, for 18 dollars 6¼ cents; required his amount of sales. *Ans.* $472.12.

20. Bought a quantity of flour, for 75 dollars; a quantity of bacon for 57 dollars 18¾ cents; and a quantity of corn, for 42 dollars 6¼ cents; for what sum must the whole be sold to make a profit of 25 dollars? *Ans.* $199.25.

SUBTRACTION OF DECIMALS.

RULE XXX.

§ 150. *For the subtraction of decimals.*

1. Set the less value under the greater, with *tenths* under *tenths*, *hundredths* under hundredths, &c., and subtract as in integers; observing to make in the right of the remainder as many decimal figures as will be equal to the *greatest number of decimal figures* in either of the given numbers.

2. When the minuend has *no decimal* figures, or not so many as the subtrahend, conceive the deficient places to be occupied by decimal 0s.

EXAMPLES.

1. To find the difference between 23.0623 and 380.75.

$$\begin{array}{r} 380.75 \\ \underline{23.0623} \\ \hline 357.6877 \end{array}$$

Having set the less quantity under the greater, with *tenths* under *tenths*, &c., we suppose the two vacant places over 23 to be occupied by 00, (§ 135;) and subtract as in integers; thus, 3 from 10 leaves 7, &c. Four decimal figures are made in the right of the remainder.

2. To find the difference between 525 and 9.87534.

$$\begin{array}{r} 525 \\ 9.87534 \\ \hline 515.12466 \end{array}$$

The places for decimals over .87534 must be regarded as occupied by 0s; thus, 4 from 10 leaves 6, &c.

EXERCISES.

1. Find the Difference between 35.804 and 360.75. *Ans.* 324.946.
2. Find the Difference between 734.06 and 2.7431. *Ans.* 731.3169.
3. Find the Difference between 57.863 and 40.736. *Ans.* 17.127.
4. Find the Difference between 12.683 and 940.05. *Ans.* 927.367.
5. Find the Difference between 734.11 and .38703. *Ans.* 733.72297.
6. Find the Difference between 78396 and 476.24 *Ans.* 77919.76.
7. Find the Difference between 57.609 and 4.7305. *Ans.* 52.8785.
8. Find the Difference between 93430 and 800.34. *Ans.* 92629.66.
9. Find the Difference between 72137 and 131.004. *Ans.* 72005.996.
10. Find the Difference between 90000 and 900.192. *Ans.* 89099.808.

11. Find the Difference between $325 and 93 dollars 6¼ cents.

$$\begin{array}{r} \$\,325.00(\tfrac{4}{4}) \\ 93.06\,\tfrac{1}{4} \\ \hline \$\,231.93\,\tfrac{3}{4} \end{array} \qquad 231 \textit{ dollars } 93\tfrac{3}{4} \textit{ cents.}$$

Expressing the 6¼ cents in a decimal of a dollar,—supplying the vacant decimal places in the upper number with 00,—and annexing, mentally, $\frac{4}{4}$, equal to a *unit*,—we say ¼ from $\frac{4}{4}$ leaves ¾; then 1 to 6 makes 7, and 7 from 10 leaves 3, &c. (§ 34).

Two decimal figures are made in the remainder, for cents or *hundredths* of a $.

12. A person having 95 dollars 6¼ cents, pays 43 dollars 18¾ cents for fuel, what sum will he have remaining? *Ans.* $51.87½.

13. If a lot of goods were purchased for $579, and sold for 650 dollars 87½ cents, what sum would be gained?
Ans. $71.87½.

14. What would be made on a quantity of lumber, bought for 225 dollars 18¾ cents, and sold for 300 dollars 50 cents?
Ans. $75.31¼.

15. Required the loss on a lot of flour, purchased for 372 dollars 12½ cents, and sold for 321 dollars 56¼ cents.
Ans. $50.56¼.

16. A merchant bought a piece of cloth for 120 dollars, and a piece of silk for 85 dollars 68¾ cents. He sold the whole of both pieces for 316 dollars 56¼ cents; what profit did he make?
Ans. $110.87½.

17. A grazier bought cattle for $160, and sheep for 56 dollars 50 cents. He sold the cattle for 225 dollars 37½ cents, and the sheep for 83 dollars 93¾ cents; what did he make by these transactions? *Ans.* $92.81¼.

18. A manufacturer purchased a quantity of raw cotton for $400, which he made into cloth at an expense of 132 dollars 6¼ cents. What profit will he make by selling the cloth for $700? *Ans.* $167.93¾.

19. A speculator purchased wheat for $344, and bacon for 88 dollars 18¾ cents. He sold his wheat for 300 dollars 75 cents, and his bacon for 100 dollars 12½ cents; what was his gain or loss by the speculation? *Ans.* Loss, $31.31¼.

20. Having on hand 125.5 tons of coal; if I sell 13.75 tons to A, 34 tons to B, 42.125 tons to C, and 5 tons to D, how many tons will I have left? *Ans.* 30.625 tons.

21. Having purchased 575.75 yards of cotton; if I sell to A and B each 125 yards, and to C and D each 93.125 yards—how many yards will I have remaining? *Ans.* 139.5 yards.

22. Bought of two persons each 1575.5 pounds of pork; of which I sold to three persons each 234.125 pounds. How many pounds of the pork purchased are still on hand?
Ans. 2448.625 pounds.

23. A farmer bought, at one time, 375 acres of land; at another time, 233.3 acres; and at another, 136.75 acres. He wishes to make his purchases amount to 1000 acres; how much land does he still want? *Ans.* 254.95 acres.

24. Bought of A 300 bushels of salt, for $137.50, and of B 275.5 bushels for $125.87½;—of which, I sold to C 325 bushels, for $200, and the remainder to D for $150.61¼. What quantity was sold to D, and what was my entire profit or loss?
Ans. 250.5 bushels to D; entire profit $87.23¾.

25. From $3780.93¾ subtract $2100.12½.

Instead of ¾ and ½ we may take their equivalent decimals.

We shall find .93¾=.9375, and .12½=.125; (§ 144,) and $3780.9375—$2100.125=$1680.8125.

In like manner perform the following exercises:

26. From $300.18¾+$25.50 subtract $16.12½.
Ans. $309.5625.

27. From $578.03½+$37.25 subtract $20.06¼.
Ans. $595.2225.

28. From $400.50 +$9.125 subtract $100.10.
Ans. $309.525.

29. From $175.56¼+$1.87½ subtract $ 75.33.
Ans. $102.1075.

30. From $1000.4 +$2.03 subtract $ .06¼.
Ans. $1002.3675.

31. Going out to collect money, I received of one person 37 dollars 25 cents, and of another 93 dollars 56¼ cents. Out of these sums having paid a debt of 99 dollars 18¾ cents, what sum have I remaining? *Ans.* $31.62½.

32. Having deposited in bank $1000, and having drawn out at different times 74 dollars 50 cents, 390 dollars 87½ cents, and 213 dollars 68¾ cents, what sum have I still in bank? *Ans.* $320.93¾.

33. Bought a house and lot in a city for $3000, and paid for improvements on the same 316 dollars 93¾ cents. If the property be sold for $4500, what amount of profit will be realized? *Ans.* $1183.06¼.

34. A gentleman who had a journey of 145¼ miles to make, traveled for three days at the rate of 39.5 miles per day. What distance then remained to be traveled? *Ans.* 26.75 miles.

35. A farmer has in one plantation 400 acres, in another 119.25 acres, and in another 230⅛ acres. If he sell 50½ acres from each, how many acres will he have left in the three plantations together? *Ans.* 597.875 acres.

36. A speculator purchased cattle for $100, mules for 79 dollars 62½ cents, and sheep for 57 dollars 31¼ cents. He sold the whole for 400 dollars 6¼ cents; what did he gain by the speculation? *Ans.* $163.12½.

37. A merchant bought cloth for $300, linen for 71 dollars 25 cents, and silk for 112 dollars 6¼ cents. He sold the cloth at a profit of 49 dollars 18¾ cents, the linen at a profit of 18 dollars 87½ cents, and the silk at a loss of 50 dollars; what did he gain or lose on the whole? *Ans.* Gained $18.06¼.

MULTIPLICATION OF DECIMALS.

RULE XXXI.

§ **151.** *For the multiplication of decimals.*

1. Multiply as in integers, and in the right of the product make as many decimal figures as there are *decimal figures in both the factors;* prefixing 0s to the product when necessary to make up the number.

2. *Integral* 0s *in the right of the multiplier* may be omitted, provided the same number of *decimal* figures be made *integral* in the multiplicand,—0s being annexed to the multiplicand, when necessary to make up the number. When the multiplier is 10, 100, &c., the product is thus immediately obtained.

EXAMPLES.

1. To multiply .19 by .5; that is, to find .5 of .19. (§ 116.)

$$\begin{array}{r} .19 \\ .5 \\ \hline .095 \end{array} \quad 95 \textit{ thousandths.}$$

Multiplying as in integers, we find the product 95; to which we prefix the 0 and the decimal point, to make three decimal figures for the three in the multiplicand and multiplier.

2. To multiply 236 by 3.4.

$$226 \times 3.4 = 802.4.$$

In the product 802.4 we have one decimal figure for the one in the multiplier, there being no decimal in the multiplicand.

3. To multiply 48.5 by 300.

$$48.5 \times 300 = 14550.0.$$

Or, rejecting the *two integral* 0s in the right of the multiplier, and making *two more integral* figures in the multiplicand,

we have $4850 \times 3 = 14550$; as before.

In like manner, $3.45 \times 100 = 345$

$3.45 \times 1000 = 3450$; and so on;

in which cases the products are immediately obtained by making as many *additional* integral figures in the multiplicand, as there are *integral* 0s in the right of the multiplier;—annexing 0s to the multiplicand, when necessary to make up the number.

☞ In the first example, if we multiply the two quantities together under the form of *vulgar fractions*, we shall have

$$\frac{19}{100}\times\frac{5}{10}=\frac{95}{1000}=.095.$$

To express the product $\frac{95}{1000}$ by a *decimal*, requires as many decimal figures as there are 0s in the denominator 1000; (§ 128;) or in the two denominators 100 and 10; that is, as many decimal figures as there are figures in the *two numerators* 19 and 5.

In general terms, the product of two decimal fractions must contain just as many decimal figures as both the factors, because, in using the decimals under the form of *vulgar fractions*, the product will have just as many 0s in its denominator as are in the denominators of both factors, and the number of figures in the decimal numerator must equal the number of 0s in the denominator.☜

EXERCISES.

1. Multiply .25 by .9, and 1.5 by .03. *Ans.* .225 and .045.
2. Multiply 38.3 by 8, and 4.75 by .5. *Ans.* 306.4 and 2.375.
3. Multiply 930 by .1, and 875 by .01. *Ans.* 93 and 8.75.
4. Multiply 300 by .04, and .379 by 1.5. *Ans.* 12 and .5685.
5. Multiply 5.76 by 9, and .031 by 80. *Ans.* 51.84 and 2.48.
6. Multiply .003 by 30, and 874 by .03. *Ans.* .090 and 26.22.
7. Multiply .876 by 4.5, and 37.4 by .39. *Ans.* 3.942 and 14.586.
8. Multiply 280 by .02, and 730 by 1.2. *Ans.* 5.6 and 876.
9. Multiply 6.74 by .01, and 89 by .001. *Ans.* .0674 and .089.
10. Multiply 53.7 by 1.4, and 60 by .006. *Ans.* 75.18 and .360.
11. Multiply 100 by .01, and 0.1 by .101. *Ans.* 1 and .0101.
12. Multiply .003 by .05, and .007 by .09. *Ans.* .00015 and .00063.

13. What will 7 cords of wood amount to, at 3 dollars 18¾ cents per cord?

The wood will cost 7 times 3 dollars 18¾ cents.

Expressing the 18¾ cents by a decimal of a dollar, (§ 140,) *we have* $3.18¾ *to be multiplied by* 7.

$$\begin{array}{r}\$3.18\tfrac{3}{4}\\ 7\\ \hline \$22.31\tfrac{1}{4}\end{array}\qquad 22\ \textit{dollars}\ 31\tfrac{1}{4}\ \textit{cents.}$$

Multiplying the ¾ by 7, we say 7 times ¾ is $\frac{21}{4}$, equal to 5¼; setting down the ¼ and carrying the 5, 7 times 8 is 56, and 5 are 61, &c..

In the product we make two decimal figures for the two in the multiplicand. (§ 132).

14. What should be paid for 9 hundred weight of tobacco, at 10 dollars 37½ cents per hundred weight? *Ans.* $93.37½.

15. What should be paid for 37 head of cattle, at 13 dollars 18¾ cents a head; and 7 mules, at 40 dollars 50 cents a head? *Ans.* $771.43¾.

16. What should be paid for 8 yards of cloth, at 9 dollars 56¼ cents a yard; and 12 yards of linen, at 87½ cents a yard? *Ans.* $87.

17. What should be paid for 25 bushels of wheat, at 1 dollar 6¼ cents a bushel; and 30 bushels of corn, at 43¾ cents a bushel? *Ans.* $39.68¾.

18. A merchant bought 50 yards of cloth, at $4 a yard; and sold the same at 6 dollars 87½ cents a yard. How much did he gain? *Ans.* $143.75.

19. Bought 100 sheep at 1 dollar 31¼ cents a head, and sold the same at 2 dollars 93¾ cents a head: what was the gain per head, and what on the whole?

Ans. Gained per head, $1.62½; on the whole $162.50.

20. Required the sum that must be paid for 3 hundred weight of bacon, at $6 per hundred weight; 4 barrels of flour, at 5 dollars 62½ cents per barrel; and 2 barrels of fish, at 7 dollars 16⅔ cents per barrel? *Ans.* $54.83⅓.

21. Required the sum that must be paid for 3 bushels of potatoes, at 87½ cents a bushel; 17 pounds of butter, at 12½ cents a pound; and 5 dozen eggs, at 8⅓ cents a dozen. *Ans.* $5.16⅔.

22. Required the sum that should be paid for 50 pounds of sugar, at 9½ cents a pound; 20 pounds of coffee, at 15¼ cents a pound; 15 pounds of rice, at 6¼ cents a pound; and 3 gallons of molasses, at 30 cents a gallon. *Ans.* $9.63¾.

23. A merchant bought 30 yards of silk at 93¾ cents per yard, and 40 yards of another kind at 1 dollar 6¼ cents per yard. He sold the first kind at 1 dollar 50 cents per yard, and the other at 1 dollar 87½ cents per yard; what profit did he make on the whole? *Ans.* $49.37½.

24. Required the sum that should be paid for 9 barrels of flour at $5.18¾ per barrel, 11 cords of wood at $2.87½ per cord, 3 tons of hay at $9¾ per ton, and 98 pounds of beef at $.05½ per pound. *Ans.* $112.95¼.

25. A farmer bought 130 acres of land at $27.25 per acre, and 237 acres at $16.93¾ per acre. He sold the first tract at $25.50 per acre, and the second at $21⅜ per acre; what did he gain or lose on the two tracts together?

Ans. Gained $824.18¾.

26. Multiply \$150.18¾ by 7 ½; that is,

find 7 times \$150.18¾, + ½ of \$150.18¾.

$$\begin{array}{r} \$150.18\frac{3}{4} \\ 7\frac{1}{2} \\ \hline 105131\frac{1}{4} \\ 7509\frac{3}{8} \\ \hline \$1126.40\frac{5}{8} \end{array} \qquad 1126 \textit{ dollars } 40\tfrac{5}{8} \textit{ cents.}$$

We first multiply by the 7, as in the preceding exercises.

To multiply by the ½ we say, ½ of 15 is 7 with one over; ½ of 10 is 5; ½ of 18 is 9, supplying the vacant place before 9 with 0; ½ of ¾ is ⅜.

We then add together the two products, and make two decimal figures, for the two in the multiplicand.

But it will often be preferable to reduce the vulgar fractions in the multiplicand and multiplier to their *equivalent decimals.*

In this example we shall have \$150.1875×7.5=\$1126.40625; which is 1126 *dollars,* 40 *cents,* 6 *mills* and 5 *tenths* of a mill.

27. A farmer sold 15¾ acres of land, at 27 dollars 37½ cents per acre; required the sum he should receive in payment. *Ans.* \$431.156'.

28. What should be paid for 3½ barrels of flour at 6 dollars 58¾ cents a barrel, and 11⅝ bushels of meal at 43¼ cents a bushel? *Ans.* \$28.084'.

29. Bought a piece of cloth containing 39¾ yards, for \$238.50; of which 20¼ yards have been sold at \$7.12½ per yard. What will be the gain or loss on the whole, if the remainder be sold at \$8.06¼ per yard? *Ans.* Gain \$63.

30. Bought 45½ hundred weight of hemp, at \$6.25 per hundred weight; which has been made into rope and bagging, at an expense of \$130.18¾. For what sum must the manufactured articles be sold to clear \$50? *Ans.* \$464.5625.

31. A trader bought 120 mules at an average price of \$39.50; of which he has sold 20 head at \$54.62½, and 33 head at \$59 a head. What will be his entire profit or loss if the rest be sold at \$30.50 a head? *Ans.* Profit \$343.

32. A barters to B 35¼ yards of broadcloth at \$7.5 a yard, for 135 yards of silk at \$.93¾ a yard,—the difference in value between the two commodities to be paid in money. Which of them must receive money, and how much?

Ans. B must pay \$139.6875.

DIVISION OF DECIMALS.

RULE XXXII.

§ **152.** *For the division of decimals.*

1. Divide as in integers, and in the right of the quotient make as many decimal figures as there are *decimal figures in the dividend* more than *in the divisor;* prefixing 0s to the quotient, when necessary to make up the number.

2. When the divisor *has more decimal figures* than the dividend, or is greater than the dividend (regarding both as *integers,*) annex *decimal* 0s to the dividend, to supply the deficiency.

3. Ciphers may always be *annexed to the remainder,* and the division continued to any required exactness,—observing that the 0s so annexed must be counted as decimal figures *belonging to the dividend.*

4. *Integral* 0s *in the right of the divisor* may be omitted, provided the same number of *integral* figures be made *decimals* in the dividend,—0s being prefixed to the dividend, when necessary to make up the number. When the divisor is 10, or 100, &c., the quotient is thus immediately obtained.

EXAMPLES.

1. To divide .965 by .5, that is, to find how often .5 is contained in .965.

$$\begin{array}{r}.5\,)\,.965\\ \hline 1.93\end{array} \qquad .965\div.5=1.93.$$

Dividing as in integers, we find the quotient 193; in which we make *two decimal figures,* since the dividend has two more decimal figures than the divisor.

2. To divide .375 by 125; that is, to find what part .375 is of 125.

$$125).375(.003$$

Having found the quotient 3, we prefix to it two 0s and the decimal point, to make *three decimal figures;* since the dividend has three decimal figures, while the divisor has none.

3. To divide 7 by 1.2.

$$1.2\overline{)\,7.0\quad}$$

$$5.8\,3' \qquad \text{Or } 5.83\tfrac{1}{3}.$$

The dividend having no decimal figure in it, while the divisor has one, we annex a decimal 0 to the dividend.

Having found the quotient figure 5, we annex a 0 to the remainder 10, and say 12 in 100, 8 times and 4 over; annexing another 0 to the 4, we say 12 in 40, 3 times, and 4 over.

Thus the division might be continued. Or, we may form a fraction $\frac{4}{12}=\frac{1}{3}$ of the remainder and divisor, and annex it to the quotient.

The three 0s annexed make three decimal figures belonging to the dividend; hence we make two decimal figures in the quotient.

4. To divide 8.4 by 300.

$$300)8.40(.028.$$

The dividend 8.4 being less than the divisor, we annex a decimal 0 to the dividend, and divide 300 into 8.40.

Or, rejecting the two *integral* 0s in the right of the divisor, and making two *integral* figures *decimals* in the dividend,—prefixing a 0 to make up the number,—

$$.084\div3=.028,$$

we divide .084 by 3, and find the same quotient as before.

In like manner, $345\div100 = 3.45$;
$345\div1000 = .345$;
$345\div10000=.0345$; and so on:

in which cases the quotient is immediately obtained, by making as many integral figures *decimals* in the dividend, as there are integral 0s in the right of the divisor,—prefixing 0s to the dividend, when necessary to make up the number.

☞ The dividend must contain just as many decimal figures as both the divisor and quotient, because the dividend is equal to the *product* of the divisor and quotient.

Thus in the first example, $.965=.5\times1.93$.

Hence also, the number of decimal places in the dividend cannot be taken less than the number in the divisor; for then the product would have a less number of decimal places than one of its factors,—which is impossible.

We prefix the 0s to the quotient, as in the second example, because in no other position of the 0s would the divisor, multiplied by the quotient, produce the dividend. ☜

EXERCISES.

1. Divide 22.36 by 4.3 and 3.25 by 1.3. *Ans*. 5.2 and 2.5.
2. Divide 12.25 by 3.5 and 87.9 by .3. *Ans*. 3.5 and 293.
3. Divide .0425 by .05 and 5 by .0625. *Ans*. .85 and 80.
4. Divide 16.776 by 7.2 and .816 by .04. *Ans*. 2.33 and 20.4.
5. Divide 1.5 by .375 and 75 by 12. *Ans*. 4 and 6.25.
6. Divide 4.9 by 70 and 7.02 by 3. *Ans*. .07 and 2.34.
7. Divide 5.85 by .65 and 5.92 by .08. *Ans*. 9 and 74.
8. Divide 15.57 by .45 and .001638 by .07.
Ans. 34.6 and .0234.
9. Divide 8 by 3.2 and 234.375 by 25. *Ans*. 2.5 and 9.375.
10. Divide .0276 by 23 and .08 by 32. *Ans*. .0012 and .0025.

In the next exercises, let the quotient be continued to thousandths, *and be expressed* by an *approximate decimal.*

11. Divide 13.29 by 2.8 and .278 by .07.
Ans. 4.746' and 3.971'.
12. Divide 2.37 by 93 and .0011 by .09. *Ans*. .025' and .012'.
13. Divide .737 by 8.9 and .09 by 8.3. *Ans*. .082' and .010'.
14. Divide 8.641 by 13 and .643 by 1.05. *Ans*. .664' and .612'.
15. Divide .023 by .03 and .013 by .074. *Ans*. .766' and .175'.

Another Method of Reducing a Vulgar Fraction to a Decimal.

§ **153.** The quotient of a less integer divided by a greater may be represented by a *proper vulgar fraction;* thus 3÷4 is $\frac{3}{4}$.

If the less integer be then divided by the greater, *decimally,* the vulgar fraction will be reduced to a decimal.

$$3 \div 4 = 3.00 \div 4 = .75\ ;\ \text{or}\ \tfrac{3}{4} = .75.$$

The application of Rule XXXII to this case, is substantially the same with that of Rule XXVIII.

16. Divide 4 by 15, or reduce $\frac{4}{15}$ to a decimal. *Ans*. .266'.
17. Divide 9 by 34, or reduce $\frac{9}{34}$ to a decimal. *Ans*. .264'.
18. Divide 13 by 120, or reduce $\frac{13}{120}$ to a decimal. *Ans*. .108'.
19. Divide 17 by 200, or reduce $\frac{17}{200}$ to a decimal. *Ans*. .085.
20. Divide 25 by 339, or reduce $\frac{25}{339}$ to a decimal. *Ans*. .073'.
21. Divide 7 by 13, or reduce $\frac{7}{13}$ to a decimal. *Ans*. .538'.
22. Divide 10 by 19, or reduce $\frac{10}{19}$ to a decimal. *Ans*. .526'.
23. Divide 21 by 121, or reduce $\frac{21}{121}$ to a decimal. *Ans*. .173'.
24. Divide 73 by 300, or reduce $\frac{73}{300}$ to a decimal. *Ans*. .243'.
25. Divide 99 by 500, or reduce $\frac{99}{500}$ to a decimal. *Ans*. .198.

26. How many gallons of wine, at 1 dollar 37½ cents per gallon, may be bought for 25 dollars and 50 cents ?

Expressing the cents *in decimals of a* $, *the number of gallons is the number of times* $1.37½ cents *is contained in* $25.5; *that is,*

$$\$25.5\div\$1.37\tfrac{1}{2},=\$25.5\div\$\tfrac{2.75}{2}.$$

But in the *Division of Federal Money,* instead of *fractions of a cent,* it will generally facilitate the operation to take their *equivalent decimals.* We have then

$25.5÷$1.375. *Ans.* 18.545' gallons.

27. What quantity of coal, at 18 dollars and 75 cents per ton, may be purchased for 13 dollars ?

$13 *will buy the same part of a ton that* $13 is of $18.75.
Ans. .693' of a ton.

28. How many hundred weight of flour, at 2 dollars 18¾ cents per hundred, may be purchased for 25 dollars ?
Ans. 11.428' hundred weight.

29. What quantity of land, at the rate of 25 dollars per acre, may be bought for 9 dollars 62¼ cents ?
Ans. .3849 of an acre.

30. How many bushels of clover seed, at 5 dollars 18¾ cents per bushel, may be bought for 30 dollars ?
Ans. 5.783' bushels.

31. How many yards of cloth, at 4 dollars and 50 cents a yard, may be purchased for 19 dollars 75 cents ?
Ans. 4.388' dollars.

32. How many barrels of corn, at 3 dollars and 85 cents per barrel, may be bought for 100 dollars ? *Ans.* 25.974' barrels.

33. What quantity of bacon, at 8 dollars 31¼ cents per hundred weight, may be purchased for 5 dollars 6¼ cents ?
Ans. .609' of a hundred weight.

34. What quantity of iron, at 45 dollars 50 cents per ton, may be bought for the sum of $7.06¼+$13.5 ?
Ans. .451' of a ton.

35. How many barrels of apples, at 2 dollars 12½ cents per barrel, may be bought for $75.83¾—$20.56¼ ?
Ans. 26.011' barrels.

36. What should be paid for a ton of hay, when .7 of a ton sells for 13 dollars 12½ cents ?

If 7 *tenths* of a ton *cost* $13.12½, 1 *tenth would be worth* $\frac{1}{7}$ *of* $13.12½; and a WHOLE TON, or 10 *tenths, would be worth* $\frac{10}{7}$ *of* $13.12½; that is, *such a part of this sum as is expressed by the* reciprocal *of* .7; or $13.12½÷.7.

We may also reason thus. *The price of a ton will be such that* .7 of the *price*, or the *price* × .7, *will be* $13.12½.

Hence $13.12½ is a *dividend*, or product *given*, and .7 a *divisor*, or one factor given to find the *quotient*, which will be the other factor. *Ans.* $18.750.

37. If 3½ cords of wood sell for 12 dollars 75 cents, what is the price per cord? *Ans.* $3.642'.

38. If 5¼ yards of broadcloth cost 21 dollars 25 cents, what should be paid for 1 yard of the same cloth? *Ans.* $4.047'.

39. If ⅝ of a lot of ground be worth 73 dollars 87½ cents, what is the whole of the lot worth at that rate? *Ans.* $118.20.

40. If 4½ cords of wood come to $9, what is the price per cord? What would 7¾ cords amount to? *Ans.* $2; and $15.50.

41. What is the price of wheat per bushel when 25⅛ bushels sell for 37 dollars 68¾ cents, and what should be paid for 40 bushels at the same rate? *Ans.* $1.50; and $60.

42. What is the price of butter per pound when 13½ pounds sell for 1 dollar 62 cents, and what ought to be paid for 145 pounds of butter at the same price? *Ans.* $.12; and $17.40.

43. Bought 50 bushels of salt for $31.25, and sold it at a profit of 25 cents per bushel. At what price per bushel was it sold? *Ans.* $.875.

44. Bought 32½ barrels of corn for $81.25, and sold it at a profit of 61¼ cents per barrel: at what price per barrel was it sold, and what was the whole profit made? *Ans.* $3.1125; and $19.906'.

45. A bought of B 1000 bushels of wheat, at $.87½ a bushel; of which he has sold to C 453½ bushels, at $.9 a bushel. At what price per bushel must the remainder be sold to produce a profit of $25 on the 1000 bushels? *Ans.* $.90.

46. A person having $300 on hand would disburse it for equal quantities of sugar and coffee. What quantity of each can he purchase, if the sugar be 9 cents and the coffee 15 cents per pound?

9 cents + 15 cents = 24 cents; then 24 cents will buy 1 pound of each. *Ans.* 1250 pounds of each.

47. A miller wishes to purchase wheat, rye, and corn, in equal quantities. The prices of these commodities being respectively $1, $.5, and $.37½ per bushel, how many bushels of each can he purchase for $500? *Ans.* 266.666' bushels of each.

EXERCISES ON CHAPTER VI.

1. What is the value of the expression

(3 *hundredths* + 23 *thousandths*) × 9 *thousandths ?*
Ans. .000477.

2. What is the value of the expression

(8 *tenths*—75 *ten-thousandths*)×21 *hundredths ?*
Ans. .166425.

3. What is the value of the expression

(34 *thousandths*+7 *hundredths*)÷3 *hundredths ?*
Ans. 3.466'.

4. What is the value of the expression

(723 *thousandths*—9 *thousandths*)÷8 *thousand ?*
Ans. .000089'.

5. What is the value of the expression

(34 *ten-thousandths*+8 *hundredths*)÷20 *thousand ?*
Ans. .000004'.

Find the answer to each of the three following questions in a vulgar fraction, in its *lowest terms.*

6. What is the value of the expression

(.25+.125+2.5—.05—.005)×.04 ? *Ans.* $\frac{141}{1250}$.

7. What is the value of the expression

(.1+.34+.09+3.2—1.375)÷5 ? *Ans.* $\frac{471}{1000}$.

8. What is the value of the expression

(80—28.5+100—50.4—90.1)÷50 ? *Ans.* $\frac{11}{50}$.

Find the answer to each of the two following questions in an integer and decimal thousandths ; *employing a mixed or complex decimal to express the exact value.*

9. What is the value of the expression

$(\frac{3}{4}+5\frac{1}{2}+10+.3\frac{1}{4}+2\frac{1}{10})-(7+\frac{2}{5}+5\frac{1}{3})$? *Ans.* $5.941\frac{2}{3}$.

10. What is the value of the expression

$(25\frac{3}{8}+3.6\frac{2}{3}+16+100\frac{1}{6})-(4\frac{1}{2}+\frac{1}{8}+10)$? *Ans.* $130.583\frac{1}{3}$.

11. Find the sum 3840+5.123+3.479+31. *Ans.* 3879.602.
12. Find the sum .7309+ 7834+834.3+.75. *Ans.* 8669.7809.
13. Find the sum 80.01+.1347+.9348+3.5. *Ans.* 84.5795.

14. Find the difference 737.68—7.3473. . . *Ans.* 730.3327.
15. Find the difference 80.893—837.83. . . *Ans.* 756.937.
16. Find the difference 376.84—37.639. . . *Ans.* 339.201

11. Find the amount of a merchant's bill for 3½ yards of clot at 7 dollars 68¾ cents per yard, 12¼ yards of silk at 1 dollar 31¼ cents per yard, and 16 skeins of silk thread at 6¼ cents a skein. *Ans.* $43.984'.

12. What quantity of iron at 45 dollars per ton, may be purchased for 28 dollars 62½ cents ? *Ans.* .636' of a ton.

13. Bought 20 barrels of flour for 102 dollars and 50 cents, and sold the same at a profit of 87½ cents per barrel: at what price per barrel was it sold, and what was the entire profit made ? *Ans*: $6 ; and $17.50.

14. If a ship sail at the rate of 130.75 miles per day, in what time ought she to sail 69.33⅓ miles ? *Ans.* .530' of a day.

15. A merchant bought 25 yards of cloth at 4 dollars 87½ cents per yard, and sold it at an entire profit of 50 dollars 68¾ cents : at what price per yard was the cloth sold ? *Ans.* $6.9025.

16. What is the price of sugar per hundred weight when ¾ hundred weight costs 6 dollars 37½ cents, and what should be paid for 5½ hundred weight of sugar at the same rate ? *Ans.* $8.5; and $46.75.

17. A farmer bought a plantation containing 400 acres, at $20½ per acre, and sold ½ of it at a profit, on that half, of $213.12½. At what rate per acre was the land sold ? *Ans.* $21.565'.

18. If ⅝ of a yard of silk cost $1.12½, what sum should be paid for 15½ yards at the same rate ? *Ans.* $27.90.

19. A person wishes to purchase a quantity of coffee, and as much rice. The coffee is at 13½ cents, and the rice at 5 cents, per pound ; what amount of each can he purchase for $15½ ? *Ans.* 83.783' pounds.

20. Allowing ¾ of a yard of cloth to cost $5.43¾, what sum ought to be paid for 13⅞ yards at the same rate ? *Ans.* $100.59375.

21. A bought of B 122½ bushels of wheat, and of C 75¼ bushels at 93¾ cents per bushel. He made 60 bushels into flour, and sold the flour at a profit of $12.50 : if he sells the remainder of the wheat at 81¼ cents per bushel, what will be his entire profit or loss ? *Ans.* Loss $4.718'.

22. A speculator bought 50 barrels of flour at $4.06¼ per barrel, and 75 bushels of wheat at $.68¾ per bushel. Having sold 20 barrels of the flour at $5 per barrel, and the whole of the wheat at $.75 per bushel, at what rate per barrel must the remainder of the flour be disposed of to make his profit $100 on the whole ? *Ans.* $6.614' per barrel.

REMARK.

The preceding Chapters, which contain the Addition, Subtraction, Multiplication, and Division of Integers and Fractions—with the notations and reductions necessary to these operations—involve the essential principles of Arithmetic; and should be fully mastered by the pupil before he is permitted to advance.

At this stage, therefore, in his arithmetical studies, it is recommended that the pupil be thoroughly examined on what precedes, and, if found deficient, be required to review.

CHAPTER VII.

TABLES OF MONEY, WEIGHTS, AND MEASURES.—REDUCTION OF MONOMIALS, POLYNOMIALS, AND CURRENCIES.

Measuring Units.

§ **154.** The *measuring unit* of a Quantity is the concrete unit, of whatever kind, by means of which the quantity is expressed *numerically*.

Thus *one pound* is the measuring unit of the quantity 5 *pounds*.

What is the measuring unit of the quantity 10 *dollars?* Of 13 yards? Of 24 days? Of 75 tons? Of 100 miles? Of 135 gallons? Of $1000?

Different Orders of Measuring Units.

§ **155.** A Quantity is often expressed by two or more *different orders* of measuring units; each lower unit being, for the most part, contained an exact number of times in the next higher.

Thus 10 *dollars* 25 *cents* is a quantity, or sum of money, expressed by *two different orders* of measuring units.

How many different orders of measuring units in the quantity 5 *pounds* 3 *ounces* of gold? In 4 *days* 7 *hours* 20 *minutes* of time? In 15 *miles* 100 *yards* 2 *feet?* In 100 *pounds* 13 *shillings* 6 *pence* 3 *farthings?*

§ **156.** In Federal Money as has been seen, (§ 138), the measuring units rise from lower to higher orders by a *tenfold* increase, as in abstract numbers.

In other kinds of quantity, the measuring units rise from lower to higher orders according to the *various scales* of increase given in the following

Tables of Money, Weights and Measures.

§ **157.** English or Sterling Money

Is the national currency of the kingdom of Great Britain.

4 farthings (*qr.*) make 1 penny, (*d.*);
12 pence, ... 1 shilling, (*s.*);
20 shillings, ... 1 pound, (£);

Also, 5 shillings make 1 *crown*, and 21 shillings 1 *guinea*.

The English pound sterling is represented by a gold coin, called a sovereign, which is valued by law in the United States at $4.84.

One *qr.* is what part of a *d.*? 1 *d.* is what part of a *s.*?
1 *s.* is what part of a £.? 1 *s.* is what part of a *crown*?

§ 158. Troy Weight

Is used in weighing *jewels*, *gold*, *silver*, *liquors*, and, generally, the most valuable commodities.

24 grains (*gr.*) make 1 pennyweight, (*dwt.* or *pwt.*);
20 pennyweights, . 1 ounce, (*oz.*);
12 ounces, ... 1 pound, (*lb.*)

One *gr.* is what part of a *dwt.*? 1 *dwt.* is what part of an *oz.*?
One ounce is what part of a *lb.*?

§ 159. Avoirdupois Weight

Is used in weighing *groceries*, all the coarser *metals*, and, generally, all coarse commodities.

16 drams (*dr.*) make 1 ounce, (*oz.*)
16 ounces, ... 1 pound, (*lb.*)
2000 pounds, ... 1 ton, (*T.*)

Occasionally, for the coarsest commodities, as *plaster*, *coal*, *iron*, *hemp*, &c.,

28 pounds (*lb.*) make 1 quarter, (*qr.*);
4 quarters, ... 1 hundred weight, (*cwt.*);
20 hundred weight, or 2240 *lb.*, 1 ton, (*T.*)

The *pound Avoirdupois* is 1 *lb.* 2 *oz.* 11 *dwt.* 16 *gr.*, Troy Weight.

One *dr.* is what part of an *oz*? 1 *oz.* is what part of a *lb.*
One *lb.* is what part of a *qr.* of a *cwt.*

§ 160. Apothecaries Weight

Is used in *compounding medicines*, which, however, are bought and sold by Avoirdupois Weight.

20 grains (*gr.*) make 1 scruple, (℈);
3 scruples, ... 1 drachm, (ʒ);
8 drachms, ... 1 ounce, (℥);
12 ounces, ... 1 pound, (℔);

The *pound* and *ounce* in Apothecaries Weight are the same as in Troy Weight. The difference between the two kinds of weight is only a difference in the divisions and subdivisions of the ounce.

One *gr.* is what part of a ℈? 1 ℈ is what part of a ʒ?
One ʒ is what part of an ℥? 1 ℥ is what part of a ℔?

§ 161. Dry Measure

Is used in measuring *grain*, *fruit*, *salt*, *coal*, and, in general, all such commodities as are estimated in the *heap* or aggregate.

2 pints (*pt.*) make 1 quart, (*qt.*);
8 quarts, ... 1 peck, (*pk.*);
4 pecks,. . . . . 1 bushel, (*bu.*);

The English *quarter*, in Dry Measure, is 8 bushels, and the *chaldron* is a coal measure of 36 bushels; but coal is usually sold by *weight*.

One *pt.* is what part of a *qt.?* 1 *qt.* is what part of a *pk.?* One *pk.* is what part of a *bu.?*

§ 162. Beer Measure

Is used in measuring *beer*, *ale*, and, in general, all malt liquors, milk, and water.

2 pints (*pt.*) make 1 quart, (*qt.*);
4 quarts, ... 1 gallon, (*gal.*);
36 gallons,. . . . 1 barrel, (*bar.* or *bbl.*);
54 gallons,. . . . 1 hogshead, (*hhd.*);

The English *firkin* is 9 gallons; also 2 *fir.* make one kilderkin, and 2 *kil.* make 1 barrel.

One *gal.* is what part of a *bbl.?* 1 *gal.* is what part of a *hhd.?*

§ 163. Wine Measure

Is used in measuring *wine*, distilled *spirits*, and, in general, all liquids excepting such as fall under Beer Measure.

4 gills (*gi.*) make 1 pint, (*pt.*);
2 pints, ... 1 quart, (*qt.*);
4 quarts,. . . . 1 gallon, (*gal.*);
31½ gallons, . . . 1 barrel, (*bar.* or *bbl.*);
63 gallons, . . . 1 hogshead, (*hhd.*);
2 hogsheads, . . 1 pipe or butt, (*pi.* or *bt.*);
2 pipes or 4 *hhd.*, 1 tun, (*tn.*);

Also 42 gallons make 1 *tierce*, and 84 *gal.* make 1 puncheon. The *gallon* in Wine Measure is .81' *gal.* in Beer Measure.

One *gi.* is what part of a *pt.* 1 *gal.* is what part of a *bbl.*

§ 164. Linear or Long Measure

Is used in measuring *lines*; that is, *length*, *distance*, *height*, &c.

12 inches (*in.*) make 1 foot, (*ft.*);
3 feet, ... 1 yard, (*yd.*);
5½ yards,. . . . . . 1 rod or pole, (*r.* or *p.*);
40 rods, ... 1 furlong, (*fur.*);
8 furlongs or 1760 *yd.* 1 mile, (*m.*);

Also, 3 miles make 1 *league*—used in expressing distances at sea. The term *barley corn* was formerly used for one *third* of an *inch*, and the term *line* is sometimes used for one *twelfth* of an inch.

A *hand* is 4 inches—used in measuring the height of horses; and a *fathom* is 6 feet—used in measuring the depth of water.

One *in.* is what part of a *ft.*? 1 *ft.* is what part of a *yd.*?
One *yd.* is what part of a *r.* or *p.*?

§ 165. Cloth Measure

Is used in measuring *cloth, silk, lace,* &c., being a species of Linear or Long Measure.

2¼	inches (*in.*) make	1 nail,	(*n.*);
4	nails,.	1 quarter,	(*qr.*);
4	quarters, ...	1 yard,	(*yd.*);

Also, 3 quarters make 1 Flemish ell; 4 *qr.* 1½ *in.* 1 Scotch ell; 5 *qr.* 1 English ell; and 6 *qr.* 1 French ell.

The *yard* in Cloth Measure is the same as in Long Measure.

One *in.* is what part of a *na.*? 1 *na.* is what part of a *qr.*?

§ 166. Square Measure

Is used in measuring *surfaces*, or any extension in *length* and *breadth*, without regard to thickness.

A *square inch* is an inch *long* and an inch *wide*; a square foot is a foot long and a foot wide; and so on.

2 *in.* long and 1 *in.* wide would make how many *square inches*?
2 *in.* long and 2 *in.* wide would make how many *square inches*?
3 *in.* long and 2 *in.* wide would make how many square inches?

144	square inches (*sq. in.*) make	1 square foot,	(*sq. ft.*);
9	square feet, ...	1 square yard,	(*sq. yd.*);
30¼	square yards,.	1 *sq.* rod, pole, or perch,	(*P.*);
40	perches or *sq. r.* or *p.*,. . .	1 rood,	(*R.*);
4	roods, or 160 *sq. r.*, ...	1 acre,	(*A.*);

Also, 640 acres make 1 *square mile*, or Section of land; and 6 *miles square*, which is 36 *sq. miles*, make a Township.

An *inch square* is an inch long and an inch wide, being the same as a square inch; so a *foot square* is the same as a square foot.

But *two inches square* is 2 *in.* long and 2 *in.* wide, which makes 4 *sq. in.*; 3 inches square is 3 *in.* long and 3 *in.* wide, or 9 *sq. in.*, &c.

4 *in*. square is how many square inches? 5 *ft*. square is how many square feet? 10 miles square is how many square miles?

§ 167. Cubic or Solid Measure

Is used in measuring solids, or any extension in *length, breadth* and *thickness*.

A *cubic inch* is an inch long, an inch wide, and an inch thick; a cubic foot is a foot long, a foot wide, and a foot thick, and so on.

2 *in*. long, 1 *in*. wide, and 1 *in*. thick would make how many *cubic inches?* 2 *in*. long, 2 *in*, wide, and 1 *in*. thick, would make how many cubic inches? 2 *in*. long, 2 *in*. wide, and 2 *in*. thick, would make how many cubic inches?

1728 cubic inches (*cu. in.*) make 1 cubic foot, (*cu. ft.*)
27 cubic feet, ... 1 cubic yard, (*cu. yd.*);
128 cubic feet,. . . . . 1 cord.

A cord of wood is usually put up 8 ft. long, 4 ft. wide, and 4 feet high. One foot in length of such a pile is called a *cord foot,* and contains 16 cubic feet.

50 cubic feet of timber are allowed to weigh a *ton*. Of round timber such a quantity is allowed for a ton as, when hewn, will make 40 cubic feet.

A *perch* of stone is estimated at 1 rod or perch, which is 16½ ft., in length, 1½ ft. in thickness, and 1 ft. in height; and contains 24¾ *cu. ft.*

231 *cu. in.* is the capacity of a *gallon* in Wine Measure, and 282 *cu. in.* is the capacity of a gallon in Beer Measure.

The British Imperial gallon contains 277.274 *cu. in.*, and the Imperial bushel, being 8 *Imp. gal.* contains 2218.192 *cu. in.*

The British Winchester bushel, which is the standard bushel in the United States, contains 2150.4 cubic inches.

§168. Circular Measure

Is used in measuring any part of the *circumference* of a *circle,* in reckoning *latitude* and *longitude,* and the motions of the heavenly bodies.

60 seconds (″) make 1 minute, (′);
60 minutes,. . . . . 1 degree, (°);
360 degrees, the *circumference of any circle.*

A *degree* it is evident, has no determinate *linear* extent; being always the 360th part of the circumference on which it is taken, it is greater or less as that circumference is greater or less.

A degree on the circumference of the earth, is about 69½ miles.

One *minute* on the circumference of the earth, is called a *geographical* or *nautical* mile; the mile of linear measure being denominated a *statute* mile.

§ 169. Measure of Time.

TIME is measured in *days* by the revolution of the earth round its *axis*, and in *years* by the revolution of the earth around he sun.

60 seconds (*sec.*) make	1 minute, (*min.*);
60 minutes, ...	1 hour, (*hr.*);
24 hours, ...	1 day, (*da.*);
7 days, ...	1 week, (*wk.*);
365 days, ...	1 common year, (*yr.*);
366 days, ...	1 leap year;
100 years, ...	1 century.

A year also consists of 12 *months*, viz: January, February, March, April, May, June, July, August, September, October, November, and December.

The number of days in each is as follows:

Thirty days has September, April, June, and November;
February has twenty-eight alone, and all the rest have thirty-one;
But Leap Year comes one year in four, when February has one day more.

Or, the fourth, eleventh, ninth, and sixth, have 30 *da.* to each affixed;
And every other 31, except the second month alone,
To which we 28 assign, till Leap Year gives it 29.

Solar, Civil, and Leap Years

§ 170. The period of the earth's revolution around the sun, is 365 *da.* 5 *hr.* 48 *min.* 49.6 *sec.* This constitutes the *solar* year, being 5 *hr.* 48 *min.* 49.6 *sec.* longer than the common *civil* year of 365 days.

To correct the error which arises from reckoning only 365 days to a year, *one day* is added to February every fourth year; and this makes the *Leap* Year of 366 days. But one day is more than the excess (5 *hr.* 48 *min.* 49.6 *sec.*) of the solar above the civil year, amounts to in 4 years.

To correct this second error, so as to preserve the civil in agreement with the solar years, the following rule has been adopted; viz: *if the number of the year is divisible by* 4 *without a remainder, it is made* LEAP YEAR; but the closing year of a century, as 1700, 1800, &c., *is not made Leap Year, unless the number is divisible by* 400, *without a remainder.*

REDUCTION OF MONOMIALS AND POLYNOMIALS.

§ **171.** A *monomial* quantity, or simply a *monomial*, is a quantity expressed by a *single name* of measuring units, (§ 154).

Thus 5 *dollars* is a *monomial;* 10 shillings is a monomial.

§ **172.** A *polynomial* quantity, or simply a *polynomial*, is a quantity expressed by *two or more names* of measuring units.

Thus 5 *dollars* 25 *cents* is a *polynomial;* 3 pounds, 10 shillings, and 6 pence, is a polynomial.

A polynomial is composed of two or more monomials, which may thence be called the *terms* of the polynomial.

Thus in the first example given, the terms are 5 *dol.* and 25 *c.*; and in the second, 3£, 10 *s.* 6 *d.*

Note.—Monomial quantities have by some been called *denominate numbers*, and *polynomials* have usually been called *compound numbers*.

REDUCTION DESCENDING.

§ **173.** *Reduction descending* consists in finding the value of a given quantity in measuring units of a *lower order*, (§ 155). The quantity is then said to be reduced to a *lower* name or *denomination.*

RULE XXXIII.

§ **174.** *To reduce a Quantity to a* LOWER DENOMINATION.

1. Multiply a *monomial* of a higher denomination, or the *highest term* of a polynomial, by that number of the next lower denomination which makes a *unit* of the higher: the *product* will be in the lower denomination.

2. This product may, in like manner, be reduced to a still lower denomination, and so on, observing that each *lower term* in a polynomial must be added to the product in the *same denomination with itself*.

3. *In reducing a* MONOMIAL FRACTION to lower denominations, the *integers* in the successive products may be reserved, and afterwards arranged as the *terms of a polynomial.*

EXAMPLE.

To reduce 5£, 14*s*. 9*d*. to pence.

$$\begin{array}{r} \pounds\,5\;\;14\,s.\;\;9\,d. \\ 20 \\ \hline 114\,s. \\ 12 \\ \hline 1377\,d. \end{array}$$

We multiply 5 £ by 20, because 20 *s*. make 1 £; the product is *shillings*—to which adding the 14 *s*., we have 114 *s*.

We next multiply the 114 *s*. by 12, because 12 *d*. make 1 *s*.; the product is *pence*—to which adding the 9*d*., we have 1377 *d*.

Thus we find 5 £ 14 *s*. 9 *d*. to be equal to 1377 *d*.

EXERCISES.

1. Reduce 4 *lb*. 7 *oz*. 13 *dwt*. to *dwt*.

Recollect that 12 *oz*. make 1 *lb*., and 20 *dwt*. make 1 *oz*. *Ans*. 1113 *dwt*.

2. Reduce 7 *lb*. 10 *dwt*. 2 *gr*. to *gr*. . . . . . *Ans*. 40562 *gr*.
3. Reduce 3 *T*. 2 *cwt*. 3 *qr*. to *qr*. . . . . . *Ans*. 251 *qr*.
4. Reduce 9 *cwt*. 1 *qr*. 13 *oz*. to *oz*. . . . . . *Ans*. 16589 *oz*.
5. Reduce 14 ℥, 2 ʒ, 12 *gr*. to *gr*. . . . . . *Ans*. 6852 *gr*.
6. Reduce 8 ℔, 1 ʒ, 15 *gr*. to *gr*. . . . . . *Ans*. 46155 *gr*.
7. Reduce 15 *bu*. 2 *pk*. 7 *qt*. to *qt*. . . . . . . *Ans*. 503 *qt*.
8. Reduce 9 *bu*. 5 *qt*. 1 *pt*. to *pt*. . . . . . . *Ans*. 587 *pt*.
9. Reduce 3 *pi*. 1 *hhd*. 40 *gal*. to *gal*. . . . *Ans*. 481 *gal*.
10. Reduce 4 *tuns*, 5 *hhd*. 3 *qt*. to *qt*. . . . . . *Ans*. 5295 *qt*.
11. Reduce 13 *m*. 7 *fur*. 25 *r*. to *r*. . . . . . *Ans*. 4465 *r*.
12. Reduce 10 *L*. 16 *fur*. 15 *p*. to *p*. . . . . *Ans*. 10255 *p*.
13. Reduce 20 *yd*. 3 *qr*. 2 *na*. to *na*. . . . . . *Ans*. 334 *na*.
14. Reduce 31 *yd*. 3 *na*. 2 *in*. to *in*. . . . . . *Ans*. 1124¾ *in*.
15. Reduce 14 *A*. 1 *R*. 20 *P*. to *P*. . . . . . *Ans*. 2300 *P*.

16. Reduce 9 *A*. 13 *P*. 4 *sq*. *yd*. to *sq*. *yd*. . *Ans*. 43957¼ *sq*. *yd*.
17. Reduce 10 *cu*. *yd*. 17 *cu*. *ft*. to *cu*. *ft*. *Ans*. 287 *cu*. *ft*.
18. Reduce 4 *cu*. *yd*. 100 *cu*. *in*. to *cu*. *in*. *Ans*. 186724 *cu*. *in*.
19. Reduce 20 *wk*. 5 *da*. 33 *hr*. 5 *min*. to *min*. *Ans*. 210785 *min*.
20. Reduce 1 *yr*. 100 *da*. 20 *hr*. 5 *min*. to *min*. *Ans*. 670805 *min*.
21. Reduce 7 *T*. 13 *cwt*. 1 *qr*. 4 *lb*. to *oz*. . *Ans*. 274688 *oz*.
22. Reduce 75 ℔, 10 ℥, 7 ʒ, 2 ℈, 11 *gr*. to *gr*. *Ans*. 437271 *gr*.
23. Reduce 3 *hhd*. 40 *gal*. 3 *qt*. 1 *pt*. to *gills*. *Ans*. 7356 *gills*.
24. Reduce 5 *L*. 2 *m*. 4 *fur*. 15 *r*. to *yards*. *Ans*. 30882½ *yd*.
25. Reduce 11 *A*. 2 *R*. 25 *P*. 25 *sq*.*yd*. to *sq*.*yd*. *Ans*. 56441¼ *sq*. *yd*.

Monomial Fractions Reduced to Integers.

26. Reduce $\frac{2}{7}$ £ to integers in shillings, &c.

$\frac{2}{7}$£ multiplied by 20 produces $\frac{40}{7}$ *s.*=5$\frac{5}{7}$ shillings, (§ 174).

Reserving the *integer* 5 *s.*, and reducing the *fraction* $\frac{5}{7}$ *s.* to pence,—

$\frac{5}{7}$ *s.* multiplied by 12 produces $\frac{60}{7}$ *d.*=8$\frac{4}{7}$ pence.

Reserving the integer 8 *d.*, and reducing the fraction $\frac{4}{7}$ *d.* to farthings,—

$\frac{4}{7}$ *d.* multiplied by 4 produces $\frac{16}{7}$ *qr.*=2$\frac{2}{7}$ farthings.

Arranging the integers reserved as the *terms of a polynomial*,

we find $\frac{2}{7}$ £=5 *s.* 8 *d.* 2$\frac{2}{7}$ *qr.*

27. Reduce .23 £ to integers in shillings, &c.

.23 £ multiplied by 20 produces 4.60 shillings, (§ 174).

Reserving the integer 4 *s.*, and reducing the fraction .60 *s.* to pence,—

.60 *s.* multiplied by 12 produces 7.20 pence.

Reserving the integer 7 *d.*, and reducing the fraction .20 *d.* to *qr.*,— 20 *d.* multiplied by 4 produces .80 farthings.

Arranging the integers reserved as the terms of a polynomial, we find .23 £=4 *s.* 7 *d.* 0.80 *qr.*

The integers found in reducing are arranged with the quantity in the lowest denomination, whether that quantity be an integer or otherwise.

28. Reduce $\frac{4}{9}$ *lb.* to integers in *oz.*, &c.
Ans. 5 *oz.* 6 *dwt.* 16 *gr.*
29. Reduce .17 *lb.* to integers in *oz.*, &c.
Ans. 2 *oz.* 0 *dwt.* 19.2 *gr.*
30. Reduce $\frac{2}{3}$ *qr.* to integers in *lb.*, &c.
Ans. 18 *lb.* 10 *oz.* 10$\frac{2}{3}$ *dr.*
31. Reduce .19 *T.* to integers in *cwt.*, &c.
Ans. 3 *cwt.* 3 *qr.* 5.6 *lb.*
32. Reduce $\frac{4}{15}$ ℥ to integers in ʒ, &c. *Ans.* 2 ʒ, 0 ℈, 8 *gr.*
33. Reduce .35 ℥ to integers in ʒ, &c. *Ans.* 2 ʒ, 2 ℈, 8 *gr.*
34. Reduce $\frac{7}{12}$ *pk.* to integers in *qt.*, &c. *Ans.* 4 *qt.* 1 *pt.* 1$\frac{1}{3}$ *gi.*
35. Reduce $\frac{9}{15}$ *pi.* to integers in *hhd.*, &c.
Ans. 1 *hhd.* 12 *gal.* 2$\frac{2}{5}$ *qt.*
36. Reduce .31 *bu.* to integers in *pk.* &c.
Ans. 1 *pk.* 1 *qt.* 1.84 *pt.*
37. Reduce .6 *tun*, to integers in *pi.*, &c.
Ans. 1 *pi.* 25 *gal.* 1.6 *pt.*

38. Reduce $\frac{387}{880}$ *m.* to integers in *fur.*, &c.
Ans. 3 *fur.* 20 *r.* 4 *yd.*

39. Reduce .4 *L.* to integers in *m.*, &c. *Ans.* 1 *m.* 1 *fur.* 24 *r.*

40. Reduce $\frac{10}{11}$ *yd.* to integers in *qr.*, &c.
Ans. 3 *qr.* 2 *na.* 1$\frac{5}{22}$ *in.*

41. Reduce .985 *yd.* to integers in *qr.* &c.
Ans. 3 *qr.* 3 *na.* 1.71 *in.*

42. Reduce $\frac{2}{3}$ *A.* to integers in *R.*, &c.
Ans. 2 *R.* 26 *P.* 20$\frac{1}{6}$ *yd.*

43. Reduce .83 *A.* to integers in *R.*, &c.
Ans. 3 *R.* 12 *P.* 24.2 *yd.*

44. Reduce $\frac{7}{12}$ *cu. yd.* to integers in *cu. ft.*, &c.
Ans. 15 *cu. ft.* 1296 *cu. in.*

45. Reduce .3 *cu. yd.* to integers in *cu. ft.*, &c.
Ans. 8 *cu. ft.* 172.8 *cu. in.*

46. Reduce $\frac{5}{14}$ *degree* to integers in *min.*, &c.
Ans. 21 *min.* 25$\frac{5}{7}$ *sec.*

47. Reduce .37 *deg.* to integers in *min.*, &c.
Ans. 22 *min.* 12 *sec.*

48. Reduce $\frac{7}{10}$ *wk.* to integers in *da.*, &c.
Ans. 4 *da.* 21 *hr.* 36 *min.*

49. Reduce .85 *wk.* to integers in *da.* &c.
Ans. 5 *da.* 22 *hr.* 48 *min.*

REDUCTION ASCENDING.

§ 175. *Reduction ascending* consists in finding the value of a given quantity in measuring units of a *higher order.* The quantity is then said to be reduced to a higher name or *denomination.*

RULE XXXIV.

§ 176. *To reduce a Quantity to a* HIGHER DENOMINATION.

1. Divide a *monominal* of a lower denomination, or the *lowest term* of a polynomial, by the number of that denomination which makes a *unit* of the next higher denomination: the *quotient* will be in the higher denomination.

2. This quotient may, in like manner, be reduced to a still higher denomination, and so on, observing that each *higher term* in a polynomial must be added to the quotient in the *same denomination with itself.*

3. *In reducing* a MONOMIAL INTEGER to higher denominations, each *remainder* may be reserved in the same denomination with *the dividend whence it is derived*, and the last quotient and the several remainders be afterwards arranged as the *terms of a polynomial.*

EXAMPLE.

To reduce 10 *s.* 6 *d.* 2 *qr.* to the denomination of £.

We take the lowest term 2 *qr.* and divide it by 4, because 4 *qr.* make 1 *d.*, a *unit* of the next higher denomination.

$$2\ qr.=\tfrac{2}{4}\ d.=\tfrac{1}{2}\ d.$$

We then add the 6*d.* to the $\tfrac{1}{2}$ *d.*, and divide by 12, because 12 *d.* make 1 *s.*, a *unit* of the next higher denomination.

$$6\tfrac{1}{2}\ d.=\frac{6\frac{1}{2}}{12}\ s.=\tfrac{13}{24}\ s.$$

We next add the 10 *s.* to the $\tfrac{13}{24}$ *s.* and divide by 20, because 20 *s.* make 1£, a unit of the next higher denomination.

$$10\tfrac{13}{24}\ s.=\frac{10\frac{13}{24}}{20}\ £=\tfrac{253}{480}\ £.$$

Thus we find 10 *s.* 6 *d.* 2 *qr.* to be equal to $\tfrac{253}{480}$£.

The same reductions performed *decimally*, will be presented thus;

2 *qr.*÷4=.5 *d.*; 6.5 *d.*÷12=.541' *s.*; 10.541' *s.*÷20=.527' £.

Another method of Reducing a Polynomial to a Fraction of a Higher Denomination.

§ **177.** A Polynomial may also be reduced to a *vulgar fraction* of a higher denomination, by reducing the given quantity to its lowest denomination, for a *numerator*, and reducing a *unit* of the higher denomination to the same lowest denomination, for a *denominator*.

Thus to reduce 10 *s.* 6 *d.* 2 *qr.* to the fraction of a £.

10 *s.* 6 *d.* 2 *qr.*=506 *qr.*; and 1 £=960 *qr.*

The fraction will then be $\tfrac{506}{960}$ £=$\tfrac{253}{480}$ £. And this fraction reduced to a decimal (§ 153) gives .527' £, the same as in the preceding example.

EXERCISES.

1. Reduce 8 *oz.* 15 *dwt.* 18 *gr.* to a fraction of a *lb.* *Ans.* $\tfrac{703}{960}$ *lb.*
2. Reduce 10 *oz.* 13 *dwt.* 20 *gr.* to a decimal of a *lb.* *Ans.* .890' *lb.*
3. Reduce 2 *qr.* 14 *lb.* 12 *oz.* to a fraction of a *cwt.* *Ans.* $\tfrac{283}{448}$ *cwt.*
4. Reduce 9 *cwt.* 1 *qr.* 10 *lb.* to a decimal of a *T.* *Ans.* .466' *T.*
5. Reduce 2 ʒ, 2 ℈, 17 *gr.* to a fraction of an ℥. *Ans.* $\tfrac{59}{160}$ ℥.
6. Reduce 3 *hhd.* 5 *gal.* 3 *qt.* to a decimal of a *tun.* *Ans.* .772' *tun.*

7. Reduce 4 *yd.* 2 *ft.* 9 *in.* to a fraction of a *r.* *Ans.* $\frac{59}{66}$ *r.*
8. Reduce 6 *fur.* 30 *p.* 4 *yd.* to a decimal of a *m.* *Ans.* .846' *m.*
9. Reduce 2 *qr.* 3 *na.* 2 *in.* to a fraction of a *yd.* *Ans.* $\frac{107}{144}$ *yd.*
10. Reduce 1 *qr.* 2 *na.* $1\frac{1}{2}$ *in.* to a decimal of a *yd.* *Ans.* .416' *yd.*
11. Reduce 8 *sq. ft.* 100 *sq. in.* to a decimal of a *sq. yd.* *Ans.* .966' *sq. yd.*
12. Reduce 3 *R.* 20 *P.* 9 *sq. yd.* to a decimal of an *A.* *Ans.* .876' *A.*
13. Reduce 20 *cu. ft.* 1000 *cu. in.* to a decimal of a *cu. yd.* *Ans.* .762' *cu. yd.*
14. Reduce 40′ 30″ to a fraction of a *deg.* *Ans.* $\frac{27}{40}$ *deg.*
15. Reduce 15 *min.* 15 *sec.* to a decimal of an *hr.* *Ans.* .254' *hr.*
16. Reduce 3 *hr.* 4 *min.* 20 *sec.* to a decimal of a *da.* *Ans.* .155' *da.*
17. Reduce 5 *s.* 10 *d.* 2 *qr.* to a fraction of a £. *Ans.* $\frac{47}{160}$ £.
18. Reduce 10 *oz.* 13 *dwt.* 4 *gr.* to a decimal of a *lb.* *Ans.* .888' *lb.*
19. Reduce 17 *lb.* 14 *oz.* 10 *dr.* to a decimal of a *cwt.* *Ans.* .159' *cwt.*
20. Reduce 5 ℥, 2 ℈, 10 *gr.* to a fraction of a ℔. *Ans.* $\frac{35}{576}$ ℔.
21. Reduce 1 *pk.* 3 *qt.* 1 *pt.* to a decimal of a *bu.* *Ans.* .359' *bu.*
22. Reduce 35 *gal.* 1 *pt.* 1 *gi.* to a decimal of a *hhd.* *Ans.* .558' *hhd.*
23. Reduce 25 *r.* 3 *yd.* 2 *ft.* to a decimal of a *m.* *Ans.* .080' *m.*
24. Reduce 50 *sq. yd.* 5 *sq. ft.* to a decimal of an *A.* *Ans.* .010' *A.*
25. Reduce 200 *da.* 14 *hr.* to a fraction of a *yr.* *Ans.* $\frac{2407}{4380}$ *yr.*
26. Reduce 175 *da.* 23 *hr.* to a decimal of a *yr.* *Ans.* .482' *yr.*

Monomial Integers Reduced to Polynomials.

27. Reduce 3531 *qr.* to a polynomial in £, *s.* &c.

4) 3 5 3 1 *qr.*
1 2) 8 8 2 *d.* 3 *qr.*
2|0) 7|3 *s.* 6 *d.*
3 £ 13 *s.* 6 *d.* 3 *qr.*

Dividing 3531 *qr.* by 4, we find 882 *d.*, with the remainder 3 *qr.*; dividing the 882 *d.* by 12, we find 73 *s.*, with the remainder 6 *d.*; dividing the 73 *s.* by 20, we find 3 £, with the remainder 13 *s.*

Arranging the last quotient 3 £ and the several remainders as the terms of a polynomial, we find 3531 *qr.* equal to 3 £ 13 *s.* 6 *d.* 3 *qr.*

28. Reduce 530 *d.* to a polynomial in £, &c. *Ans.* 2 £ 4 *s.* 2 *d.*

29. Reduce 874 *dwt.* to a polynomial in *lb.*, &c.
Ans. 3 *lb.* 7 *oz.* 14 *dwt.*

30. Reduce 1000 *dr.* to a polynomial in *lb.*, &c.
Ans. 3 *lb.* 14 *oz.* 8 *dr.*

31. Reduce 785 *lb.* to a polynomial in *cwt.*, &c.
Ans. 7 *cwt.* 0 *qr.* 1 *lb.*

32. Reduce 870 ℈ to a polynomial in ℔, &c. *Ans.* 3 ℔, 2 ʒ.

33. Reduce 748 ʒ to a polynomial in ℔, &c. *Ans.* 7 ℔, 9 ℥, 4 ʒ.

34. Reduce 62 *pt.* to a polynomial in *pk.*, &c. *Ans.* 3 *pk.* 7 *qt.*

35. Reduce 730 *qt.* to a polynomial in *bu.*, &c.
Ans. 22 *bu.* 3 *pk.* 2 *qt.*

36. Reduce 890 *bbl.* to a polynomial in *tuns*, &c.
Ans. 111 *tuns*, 1 *hhd.*

37. Reduce 75 *hhd.* to a polynomial in *tuns*, &c.
Ans. 18 *tuns*, 1 *pi.* 1 *hhd.*

38. Reduce 200 *ft.* to a polynomial in *r.*, &c. *Ans.* 12 *r.* 2 *ft.*

39. Reduce 540 *yd.* to a polynomial in *fur.*, &c.
Ans. 2 *fur.* 18 *r.* 1 *yd.*

40. Reduce 1000 *r.* to a polynomial in *L.*, &c. *Ans.* 1 *L.* 1 *fur.*

41. Reduce 375 *na.* to a polynomial in *yd.*, &c.
Ans. 23 *yd.* 1 *qr.* 3 *na.*

42. Reduce 4750 *sq. in.* to a polynomial in *sq. yd.*, &c.
Ans. 3 *sq. yd.* 5 *ft.* 142 *in.*

43. Reduce 7562½ *sq. yd.* to a polynomial in *A.*, &c.
Ans. 1 *A.* 2 *R.* 10 *P.*

44. Reduce 9374 *cu. in.* to a polynomial in *cu. ft.*, &c.
Ans. 5 *cu. ft.* 734 *in.*

45. Reduce 4034″ to a polynomial in *deg.*, &c. *Ans.* 1° 7′ 14″.

46. Reduce 371′ to a polynomial in *deg.*, &c. *Ans.* 6° 11′.

47. Reduce 3875 *sec.* to a polynomial in *hr.*, &c.
Ans. 1 *hr.* 4 *min.* 35 *sec.*

48. Reduce 4375 *min.* to a polynomial in *da.*, &c.
Ans. 3 *da.* 55 *min.*

49. Reduce 3470 *hr.* to a polynomial in *wk.*, &c.
Ans. 20 *wk.* 4 *da.* 14 *hr.*

50. Reduce 4831 *d.* to a polynomial in £, &c.
Ans. 20 £ 2 *s.* 7 *d.*

51. Reduce 3743 *d.* to a polynomial in £, &c.
Ans. 15 £ 11 *s.* 11 *d.*

52. Reduce 335 *lb.* to a polynomial in *cwt.*, &c.
Ans. 2 *cwt.* 3 *qr.* 27 *lb.*

53. Reduce 3735 ℈ to a polynomial in ℔, &c.
Ans. 12 ℔, 11 ℥, 5 ʒ.

54. Reduce 17630″ to a polynomial in *deg.*, &c.
Ans. 4° 53′ 50″.

A Polynomial Reduced to the Denomination of either of its Terms.

§ 178. A Polynomial may be reduced to the denomination of either of its terms, by reducing the other terms to that denomination, and adding together the several parts.

EXAMPLE.

To reduce 7£ 10 *s.* 8 *d.* 2 *qr.* to *shillings.*

By Rule XXXIII, 7£=140 *s.*; and by Rule XXXIV, 8 *d.* 2 *qr.*=.708' *s.*;

then 7£ 10 *s.* 8 *d.* 2 *qr.*=140 *s.*+10 *s.*+.708' *s.*=150.708' *s.*

55. Reduce 9 *lb.* 8 *oz.* 15 *dwt.* 5 *gr.* to *dwt.* *Ans.* 2335.208' *dwt.*
56. Reduce 2 *T.* 15 *cwt.* 3 *qr.* 18 *lb.* to *cwt.* *Ans.* 55.910' *cwt.*
57. Reduce 25 *bu.* 3 *pk.* 3 *qt.* 1 *pt.* to *pk.* *Ans.* 103.437' *pk.*
58. Reduce 5 *tuns,* 3 *hhd.* 20 *gal.* 1 *qt.* to *gal.* *Ans.* 1469.25 *gal.*
59. Reduce 4 *m.* 5 *fur.* 30 *r.* 3 *yd.* to *r.* *Ans.* 1510.545 *r.*
60. Reduce 3 *A.* 2 *R.* 19 *P.* 5 *sq. yd.* to *P.* *Ans.* 579.165' *P.*
61. Reduce 6 *tuns,* 2 *hhd.* 35 *gal.* 1 *pt.* to *tuns.* *Ans.* 6.639' *tuns.*
62. Reduce 12 *A.* 3 *R.* 21 *P.* 25 *sq. yd.* to *A.* *Ans.* 12.886' *A.*
63. Reduce 10 *T.* 15 *cwt.* 1 *qr.* 25 *lb.* to *cwt.* *Ans.* 215.473 *cwt.*
64. Reduce 25 *L.* 2 *m.* 7 *fur.* 30 *p.* to *fur.* *Ans.* 623.75 *fur.*

Cubic Measure Reduced to Gallons, Bushels, &c.

§ 179. Cubic measure may be reduced to *gallons* in Beer or Wine Measure, or to *bushels* in Dry Measure, by dividing the number of cubic inches by the number of cubic inches in a gallon or bushel, respectively. (§ 167).

EXAMPLE.

65. How many bushels of wheat would be contained in a box, the capacity of which is 100 *cu. ft.* 500 *cu. in.*?

100 *cu. ft.* 500 *cu. in.*=173300 cubic inches;

and 2150.4 *cu. in.* make 1 *bushel;* then 173300÷2150.4= 80.589' *bushels.*

66. How many bushels of salt could be put into a receptacle which measures 2160 *cu. ft.* 1000 *cu. in.*? *Ans.* 1736.179' *bu.*

67. How many barrels of water will be contained in a cistern whose capacity is 25000 *cu. ft.* 1500 *cu. in.*?

Ans. 4255.466' *bar.*

68. How many barrels of wine will be contained in a vat whose capacity is found to be 730 *cu. ft.* 49 *cu. in.*?

Ans. 173.364' *bar.*

Coins and Currency.

§ 180. The *coin*, or *specie*, of a country, consists of pieces of metal, usually gold, silver, or copper, but in some countries *platinum*, of fixed value, and stamped by public authority—to be used, and to circulate, as *money*.

The gold coins of the United States are the *eagle*, *half-eagle*, and *quarter-eagle;* the silver coins are the *dollar*, *half-dollar*, *quarter-dollar*, *dime*, and *half-dime;* the copper coins are the *cent*, and *half-cent*.

§ 181. The coins of one country will circulate as money in other countries, at values corresponding, very nearly, to the quantity and purity of the metal they contain. Thus in the United States we have in circulation the English sovereign, the Mexican dollar, and other foreign coins.

§ 182. The *Currency* of a country consists of its circulating coin, together with bank notes considered as representing coin or specie, and, occasionally, notes or bills issued by Government.

The Fineness of Gold—how expressed.

§ 183. The degree of purity or fineness of gold is expressed by *carats*. Thus pure gold being combined with some baser metal, called *alloy*, if 20 parts in every 24 of the compound be pure gold, the alloyed gold is 20 *carats* fine.

In like manner 21 parts of pure gold to 24 of the compound, would produce gold 21 carats fine; and so on.

Standard Purity and Weight of U. S. Coins.

§ 184. By an act of Congress, passed in 1837, the gold and silver coins of the United States must contain 900 parts of *pure metal* to 100 of *alloy*.

The alloy of the gold coins is composed of silver and copper, the silver not to exceed the copper in weight. The alloy of the silver coins is pure copper. The copper coins are pure copper.

The Eagle is required to weigh 258 grains; the Dollar, 412½ grains; and the Cent, 168 grains. The half-eagle, half-dollar, &c., weigh half as much as the eagle, dollar, &c., respectively.

The use of the alloy in gold and silver coins, is, to produce greater hardness in the metal, and thus render them less liable to wear in being often handled.

Reduction of Currencies.

§ 185. The *Federal Currency* of the United States was established by Congress in 1786. At that time, the currency consisting in the bills or notes of the individual States, in the denominations £, *s.*, &c., had fallen below its nominal value; and in different degrees in different States.

Hence the *pound, shilling*, &c., in those depreciated currencies, came to be of different values in Federal money, in different States; and those values have continued in use, to some extent, up to the present time.

Recollecting then that the difference in value belongs to the *shilling*, and not to the *dollar*, we have the following

Table of Values of a Shilling.

In New England, *Va. Ky.* and *Tenn.*	6 *s.*=$1,	or 1 *s.*=$16\frac{2}{3}$ *cts.*
In New York, *N. Car.* and Ohio,	8 *s.*=$1,	or 1 *s.*=$12\frac{1}{2}$ *cts.*
In New Jersey *Penn. Del.* and *Md.*	$7\frac{1}{2}$ *s.*=$1,	or 1 *s.*=$13\frac{1}{3}$ *cts.*
In South Carolina and Georgia,	$4\frac{2}{3}$ *s.*=$1,	or 1 *s.*=$21\frac{3}{7}$ *cts.*

In some of the new States, the shilling is valued according to the New England Currency, in others according to the New York currency, and others again adhere exclusively to Federal money.

The Pound Sterling.

§ 186. The English pound sterling, which is represented by a gold coin called a *sovereign*, is valued by law in the United States at $4.84.

The *intrinsic* value of the sovereign, that is, the value corresponding to the quantity and purity of metal it contains, is $4.861. Its *marketable* value, or the sum for which it passes with money dealers, varies from $4.83 to $4.86.

Taking the sovereign or pound sterling at its legal value, we shall find $4\frac{16}{121}$ shillings sterling=$1, or 1 *s. ster.*=$24\frac{1}{5}$ cts.

Federal and English Money Reduced—the one to the other.

RULE XXXV.

§ 187. (1.) *To reduce Federal to English Money.*

Multiply Federal money, expressed in the denomination of dollars, by the number of shillings in $1; the product will be *shillings.*

(2.) *To reduce English to Federal Money.*

Divide English money, expressed in the denomination of shillings, by the number of shillings in $1 ; the quotient will be *dollars.*

EXAMPLES.

1. To reduce $275.18¾ to sterling money, reckoning the £ *ster.* at $4.84.

$1 being $4\frac{16}{121}$ *s. ster.* we have

$$\$275.1875\times 4\tfrac{16}{121}=1137.1384'\,s.\ ster.$$

Reducing to £, &c., we find 1137 *s.*=56£ 17 *s.*; and .1384' *s.* =1 *d.* 2.6' *qr.*

Hence $275.18¾=56£ 17 *s.* 1*d.* 2.6' *qr.*, sterling.

2. To reduce 3£ 13 *s.* 6 *d.* sterling to Federal money.

By reduction, we find 3£ 13 *s.* 6 *d.*=73.5 shillings, (§ 178), and 73.5 *s.* $\div 4\frac{16}{121}=\$17.787$.

EXERCISES.

1. Reduce 2 *s.* 3 *d.* in New England, to Federal money
Ans. $.375.

2. Reduce 5 *s.* 6 *d.* in New York, to Federal money.
Ans. $.687'.

3. Reduce 14 *s.* 8 *d.* in Pennsylvania, to Federal money.
Ans. $1.955'.

4. Reduce 16 *s.* 9 *d.* in Georgia, to Federal money.
Ans. $3.589'.

5. Reduce 100£ 15 *s.* 10 *d.* sterling to Federal money, according to the legal value of the £ sterling in the United States.
Ans. $487.828'.

EXERCISES ON CHAPTER VII.

1. What will 2 *lb.* 8 *oz.* 13 *dwt.* of silver ware amount to, at $.31¼ per pennyweight ?

The whole quantity must be expressed in dwt. and multiplied by $.31¼. *Ans.* $204.0625.

2. What will 4 *cwt.* 3 *qr.* 19 *lb.* of hemp amount to, at $6.87½ per hundred weight ?

The whole quantity must be expressed in cwt., and multiplied by $6.87½. *Ans* $33.818'.

3. What will 2 *bu.* 3 *pk.* 3 *qt.* of strawberries amount to, at $.12½ per quart ? *Ans.* $11.375.

4. What will 2 *hhd.* 40 *gal.* 3 *qt.* of beer amount to, if retailed at $.03 per pint ? *Ans.* $35.70.

5. What will 3 *bbl.* 16 *gal.* 3 *qt.* of brandy amount to, if retailed at $.06¼ per gill? *Ans.* $222.5.

6. What will 10 *T.* 13 *cwt.* 2 *qr.* 23 *lb.* of coal amount to, at $5.37½ per ton? *Ans.* $57.431'.

7. How many pounds of bread may be bought for $7.84¼, at the rate of 2½ cents per ounce? *Ans.* 19.606' *lb.*

8. How many barrels of ale may be purchased for $95.87½, at the rate of 15 cents per quart? *Ans.* 4.438' *bar.*

9. How many pipes of wine may be purchased for $450.50, at the rate of 18¾ cents per pint? *Ans.* 2.383' *pipes.*

10. Required the sum that should be paid for 1 *m.* 3 *fur.* 20 *r.* of fencing, at $.75 per rod. *Ans.* $345.

11. Required the sum that should be paid for 13 *yd.* 1 *qr.* 3 *na.* of gold lace, at $.93¾ per *yd.* *Ans.* $12.597'.

12. Required the sum that should be paid for 3 *A.* 2 *R.* 20 *P.* of meadow land, at $25 per acre. *Ans.* $90.625.

13. Required the sum that should be paid for excavating 100 *cu. yd.* 500 *cu. ft.* of earth, at $.91¼ per *yd.* *Ans.* $108.147'.

14. Required the sum that should be paid a laborer for 3 years 7½ months' wages, at $125 per annum.
Ans. $453.125.

15. A townsman bought a lot containing 1000¾ *sq. yd.* of ground, at $100 per acre; what sum did he pay for it?
Ans. $20.67'.

16. A merchant invested the profits of five years' business, amounting to $7349.31¼, in land at $24.12½ per acre. How much land did he purchase? *Ans.* 304 *A.* 2 *R.* 21.44 *P.*

17. An iron-monger bought a quantity of iron at $45 per ton, and sold 13 *cwt.* 2 *qr.* 15 *lb.* of the same, at $62½ per ton. What profit did he make on the quantity sold?
Ans. $11.928'.

18. How many barrels of water will fill a cistern, the capacity of which is 13000 cubic feet? *Ans.* 2212.765' *bar.*

19. How many bushels of wheat will fill a granary, the capacity of which is 4360 cubic feet? *Ans.* 3503.571' *bu.*

20. A merchant bought in New York 135 *yd.* 3 *qr.* of linen, at 2 *s.* 3 *d.* per *yard*, and 74 *yd.* 2½ *qr.* of silk at 6 *s.* 9 *d.* per yard. Required the whole amount in Federal money.
Ans. $101.144'.

21. A farmer sold in Philadelphia 400 *bu.* 3 *pk.* of wheat, at 6 *s.* 11 *d.* per bushel, and 175¼ *bu.* of oats, at 3 shillings per bushel. Required the whole amount in Federal money.
Ans. $439.644'.

CHAPTER VIII.

ADDITION, SUBTRACTION, &C., OF MONOMIALS AND POLYNOMIALS. DUODECIMALS.

ADDITION, &C., OF MONOMIALS.

§ 188. *Dissimilar* Monomials in the *same kind of measure*, may be reduced to similar monomials, and then added or subtracted.

Thus, to add together ¾£ and ⅔ *s.*

¾£=15 *s.*=180 *d.*; and ⅔ *s.*=8 *d.* Then 180 *d.*+8 *d.*=188 *d.*

RULE XXXVI.

§ 189. *To add or subtract* DISSIMILAR MONOMINALS in the same *kind of measure.*

Express the given quantities in the *same denomination*, by means of reduction, and then add or subtract.

EXAMPLE.

To find the sum of 3£, ⅓ *s.* and 8½ *d.* in the denomination of *pence.*

By reduction, 3£=60 *s.*=720 *d.*; and ⅓ *s.*=4 *d.*;
then 720 *d.*+4 *d.*+8½ *d.*+732½ *d.*

EXERCISES.

1. Find the sum of ¼ *T.*, 2 *cwt.*, and ½ *qr.*, in *lb.* *Ans.* 798 *lb.*
2. Find the difference between 3 *s.* and 9¼ *d.*, in *d.* *Ans.* 26¾ *d.*
3. Find the sum of 10 *bu.*, 3½ *pk.*, and 2 *qt.*, in *bu.* *Ans.* 10$\frac{15}{16}$ *bu.*
4. Find the difference between 3 *hhd.* and 4½ *gal.*, in *qt.* *Ans.* 738 *qt.*
5. Find the sum of ¼ *m.*, ¾ *fur.*, and 20 *r.*, in *m.* *Ans.* $\frac{13}{32}$ *m.*
6. Find the difference between 3 *A.* and 30½ *P.*, in *P.* *Ans.* 449½ *P.*
7. Find the sum of .4 *lb.*, 3 *oz.*, and .5 *dwt.*, in *dwt.* *Ans.* 156.5 *dwt.*
8. Find the difference between .3 *T.* and 7.3 *cwt.*, in *cwt.* *Ans.* 1.3 *cwt.*
9. Find the sum of 3.7 *bu.*, 3 *pk.*, and 4 *qt.*, in *bu.* *Ans.* 4.575 *bu.*
10. Find the difference between .45 *m.* and .3 *fur.*, in *m.* *Ans.* .4125 *m.*

11. Find the sum of .2 *A.*, 3.1 *R.*, and 4 *P.*, in *sq. yd.* *Ans.* 4840 *sq. yd.*

12. Find the difference between .75 *A.* and 1 *R.*, in *sq. yd.* *Ans.* 2420 *sq. yd.*

Multiplication and Division of Monomials.

§ 190. In multiplication, the multiplier can be considered only as expressing *repetitions* of the multiplicand, or a *part* of the multiplicand.

§ 191. In Division, when the answer to be found is the number of times the dividend *contains the divisor*, or the *part* the dividend is of the divisor, these two terms must be taken in the *same denomination* of units.

For example, to find how many times 15 *s.* is contained in 3£.

Reducing, we find 3£=60 *s.*; then 15 *s.* in 60 *s.*, 4 times.

Or, 15 *s.*=$\frac{15}{20}$£=$\frac{3}{4}$£ ; and $\frac{3}{4}$£ in 3£, 4 times.

13. How many yards of silk, at 5 shillings per yard, can be purchased for 9½ £ ? *Ans.* 38 *yd.*

14. How many pounds of butter, at 9 pence per pound, can be purchased for 21¼ shillings ? *Ans.* 28⅓ *lb.*

15. A person having a lot of ground which contained 1¼ acres, sold 39 *P.* of it to his neighbor. What part of the lot did he sell ? *Ans.* .195 of it.

16. A laborer who had 25 rods of ditching to execute, has accomplished 51½ yards of it. What part of the whole work has he accomplished ? *Ans.* .374' of it.

17. A farmer sowed 57¼ bushels of rye in a field, and found that it was at the rate of 3½ *pk.* per acre. How many acres did he sow ? *Ans.* 65$\frac{3}{7}$ *A.*

18. An agriculturist bought, at one time, 2 *T.* of plaster, and at another, 15½ *cwt.* How many acres of meadow can he sow with the whole, at the rate of 100 *lb.* per acre ? *Ans.* 62$\frac{4}{25}$ *A.*

19. A wine merchant has 3 *tuns* and 1 *pipe* of wine, which he wishes to put into barrels of 31½ *gal.* each. How many barrels will be required for the whole ? *Ans.* 28 *bbl.*

20. Bought at different times, in adjoining parcels, 3 *A.*, 3½ *R.*, and 20 *P.* of ground. I wish to divide the whole into lots of 40 *P.* each ; how many lots will there be ? *Ans.* 16 *lots.*

ADDITION OF POLYNOMIALS.

§ 192. Two or more polynomials in the *same kind of measure*, might be reduced to similar monomials, and, under the monomial form, might be added or subtracted.

In like manner, a polynomial might be multiplied or divided.

But polynomials may be added, &c., under the polynomial form,—such operations being usually called *Compound Addition, Compound Subtraction*, &c.

RULE XXXVII.

§ 193. *For Polynomial or Compound Addition.*

1. Set the polynomials with similar terms one under another, in separate columns.

2. Proceeding from right to left, add up each column of similar terms, and under each set its amount, if less than a unit of the next higher denomination.

3. *If not less than such unit*, divide the amount of the column by that number of its own denomination which makes a unit of the next higher; set the *remainder*, if any, under the column, and add the *quotient* to the next column of similar terms.

EXAMPLE.

To add together 13£ 7 *s.* 2 *d.*, 49£ 18 *s.* 4 *d.*, and 84£ 9 *s.* 5 *d.*

£	*s.*	*d.*
13	7	2
49	18	4
84	9	5
147	14	11

Having set *pounds* under *pounds*, shillings under shillings, &c., we add up the column of *d.*, and set down the amount 11 *d.*, since it is less than 1 *s.*, a unit of the next higher denomination.

Adding up the column of *s.*, we find the amount to be 34 *s.*, which, being more than 1£, we divide by 20, since 20*s.*=1£.

Setting down the remainder 14 *s.* we add the quotient to the column of £, and find the whole sum to be

147£ 14 *s.* 11 *d.*

By this Rule, an amount in a lower denomination is reduced, when practicable, to units of the next higher denomination; and all units of the same denominaton are collected into one sum. (§ 23).

EXERCISES.

1. Add together 125£, 13 *s.* 5 *d.*, 19£, 4 *s.* 10 *d.* 2 *qr.*, and 12£, 16 *s.* 8 *d.* 3 *qr.* *Ans.* 157£, 15 *s.* 0 *d.* 1 *qr.*

2. Add together 23 *lb.* 8 *oz.* 16 *dwt.*, 36 *lb.* 5 *oz.* 8 *dwt.* 16 *gr.*, and 300 *lb.* 2 *oz.* 9 *dwt.* 13 *gr.* *Ans.* 360 *lb.* 4 *oz.* 14 *dwt.* 5 *gr.*

3. Add together 3 *T.* 9 *cwt.* 2 *qr.* 16 *lb.*, 10 *T.* 15 *cwt.* 1 *qr.*, and 54 *T.* 7 *cwt.* 3 *qr.* 20 *lb.* *Ans.* 68 *T.* 12 *cwt.* 3 *qr.* 8 *lb.*

4. Add together 56 ℔, 7 ℥, 5 ʒ, 2 ℈, 13 *gr.*, 25 ℔, 6 ℥, 7 ʒ, and 5 ℔, 10 ℥, 3 ʒ, 1 ℈, 19 *gr.*
Ans. 88 ℔, 1 ℥, 0 ʒ, 1 ℈, 12 *gr.*

5. Add together 13 *bu.* 2 *pk.* 7 *qt.* 1 *pt.*, 150 *bu.* 1 *pk.* 5 *qt.*, and 200 *bu.* 3 *pk.* 5 *qt.* 1 *pt.* *Ans.* 365 *bu.* 0 *pk.* 2 *qt.*

6. Add together 3 *hhd.* 20 *gal.* 3 *qt.*, 29 *hhd.* 13 *gal.* 2 *qt.*, and 200 *hhd.* 12 *gal.* 1 *qt.* *Ans.* 232 *hhd.* 46 *gal* 2 *qt.*

7. Add together 4 *m.* 5 *fur.* 20 *p.*, 29 *m.* 3 *fur.* 16 *p.* 4 *yd.*, and 34 *m.* 7 *fur.* 13 *p.* 1 *yd.* *Ans.* 69 *m.* 0 *fur.* 9 *p.* 5 *yd.*

8. Add together 15 *yd.* 3 *qr.* 1 *na.*, 75 *yd.* 3 *qr.* 3 *na.* 1 *in.*, and 100 *yd.* 1 *qr.* 2 *na.* 1 *in.* *Ans.* 192 *yd.* 0 *qr.* 2 *na.* 2 *in.*

9. Add together 24 *A.* 3 *R.* 20 *P.*, 100 *A.* 2 *R.* 16 *P.* 4 *sq. yd.*, and 95 *A.* 1 *R.* 29 *P.* 20 *sq. yd.*
Ans. 220 *A.* 3 *R.* 25 *P.* 24 *sq. yd.*

10. Add together 200 *A.* 1 *R.* 24 *P.* 20 *sq. yd.*, 50 *A.* 2 *R.*, and 500 *A.* 3 *R.* 19 *P.* 16 *sq. yd.*
Ans. 751 *A.* 3 *R.* 4 *P.* 5¾ *sq. yd.*

11. A farmer raised from one field 150 *bu.* 3 *pk.* of wheat, from another 75 *bu.* 1 *pk.* 7 *qt.*, and from another 200 *bu.* 5 *qt.* What quantity did he raise in all? *Ans.* 426 *bu.* 1 *pk.* 4 *qt.*

12. A merchant has in one piece 34 *yd.* 3 *qr.* of cloth, in another 21 *yd.* 2 *qr.*, and in two others each 19 *yd.* 3½ *qr.* How many yards has he in the four pieces? *Ans.* 96 *yd.*

13. An agriculturist sold at one time 3 *T.* 19 *cwt.* 2 *qr.* of hemp, at another 5 *T.* 13 *cwt.*, and at another 2 *T.* 16 *cwt.* 3 *qr.* 20 *lb.* What amount did he sell?
Ans. 12 *T.* 9 *cwt.* 1 *qr.* 20 *lb.*

SUBTRACTION OF POLYNOMIALS.

RULE XXXVIII.

§ 194. *For Polynomial or Compound Subtraction.*

1. Set the less polynomial under the greater, with similar terms one under the other.

2. Proceeding from right to left, subtract each lower term from the one above it, and underneath set the remainder.

3. *If the lower term exceed the upper*, add to the upper term that number of its *own denomination* which makes a *unit* of the next higher; from the sum subtract the lower term, and add 1 to the next lower term, before subtracting it.

EXAMPLES.

1. To subtract 85£, 13 *s.* 7 *d.* from 250£, 9 *s.* 10 *d.*

£,	*s.*	*d.*
250	9	10
85	13	7
164	16	3

Having set the less polynomial under the greater, with *pounds* under *pounds*, &c., we subtract 7*d.* from 10*d.*, and set down the remainder 3 *d.*

The next lower term 13 *s.* being greater than the upper term 9 *s.*, we add 20 *s.* to 9 *s.*, since 20 *s.*=1£. From the sum 29 *s.* we subtract 13 *s.*, and set down the remainder 16 *s.*

Then adding 1 to the 5, we say 6 from 10 leaves 4, &c.

2. To subtract 45£, 7 *s.* 3 *d.* from 150£.

£,	*s.*	*d.*
150	0	0
45	7	3
104	12	9

As we cannot take 3 *d.* from 0 *d.*, we add 12 *d.*=1 *s.*, and say 3 *d.* from 12 *d.* leaves 9 *d.* Then 1 to 7 *s.* makes 8 *s.*, and since we cannot take 8 *s.* from 0 *s.*, we add 20, and say 8 *s.* from 20 *s.* leaves 12 *s.* Then 1 to 5 makes 6, and 6 from 10 leaves 4, &c.

The difference between two polynomials is not changed by adding, to any upper term, a quantity equal to the unit added to the next lower term.

EXERCISES.

1. From 60£, 17 *s.* subtract 35£, 13 *s.* 6 *d.*
Ans. 25£, 3 *s.* 6 *d.*

2. From 200 *lb.* 9 *oz.* 1 *dwt.* subtract 180 *lb.* 10 *oz.*
Ans. 19 *lb.* 11 *oz.* 1 *dwt.*

3. From 150 *T.* 13 *cwt.* subtract 75 *T.* 3 *cwt.* 1 *qr.*
Ans. 75 *T.* 9 *cwt.* 3 *qr.*

4. From 433 ℔, 3 ℥, 2 ʒ, subtract 93 ℔, 10 ℥.
Ans. 339 ℔, 5 ℥, 2 ʒ.

5. From 100 *bu.* 2 *pk.* subtract 21 *bu.* 1 *pk.* 1 *qt.*
Ans. 79 *bu.* 0 *pk.* 7 *qt.*

6. From 21 *T.* 2 *hhd.* 3 *gal.* subtract 3 *T.* 13 *gal.*
Ans. 18 *T.* 1 *hhd.* 53 *gal.*

7. From 275 *L.* 2 *m.* subtract 75 *L.* 1 *m.* 5 *fur.*
Ans. 200 *L.* 0 *m.* 3 *fur.*

8. From 150 *yd.* 3 *qr.* 2 *na.* subtract 2 *qr.* 3 *na.*
Ans. 150 *yd.* 0 *qr.* 3 *na.*

9. From 123 *A.* 2 *R.* subtract 30 *A.* 3 *R.* 13 *P.*
Ans. 92 *A.* 2 *R.* 27 *P.*

10. From 200 *A.* 3 *R.* 20 *P.* subtract 30 *A.* 50 *P.*
Ans. 170 *A.* 2 *R* 10 *P.*

11. A jeweler purchased 34 *lb.* 9 *oz.* 13 *dwt.* of silver ware, of which he has sold 19 *lb.* 4 *oz.* 18 *gr.* What quantity has he remaining?
Ans. 15 *lb.* 5 *oz.* 12 *dwt.* 6 *gr.*

12. An agriculturist raised 30 *T.* 13 *cwt.* 1 *qr.* of hemp, of which he has sent to market 21 *T.* 15 *cwt.* 21 *lb.* What quantity of hemp has he still on hand?
Ans. 8 *T.* 18 *cwt.* 0 *qr.* 7 *lb.*

13. A farmer raised 500 *bu.* 3 *pk.* 7 *qt.* of wheat. Having sold 300 *bu.* 2 *pk.* 5 *qt.* of this crop, what quantity of wheat has he still unsold?
Ans. 200 *bu.* 1 *pk.* 2 *qt.*

14. A vintner purchased 3 *T.* 1 *hhd.* 40 *gal.* 2 *qt.* of wine, of which he has sold 1 *T.* 3 *hhd.* 47 *gal.* 1 *pt.* What quantity of wine has he yet unsold?
Ans. 1 *T.* 1 *hhd.* 56 *gal.* 1 *qt.* 1 *pt.*

15. A merchant bought a bale of cotton containing 400 *yd.* 3 *qr.* Having sold 139 *yd.* 3 *qr.* 2 *na.* of this purchase, how many yards of the cotton remain on hand ?

Ans. 260 *yd.* 3 *qr.* 2 *na.*

16. A speculator bought a tract of land containing 960 *A.* 2 *R.* 26 *P.* Having sold from the tract to the amount of 509 *A.* 3 *R.*, how many acres of it remain unsold ?

Ans. 450 *A.* 3 *R.* 26 *P.*

17. A merchant bought at one time 4 *T.* 19 *cwt.* of hemp, at another 3 *T.* 2 *qr.*, and at another 1 *T.* 13 *cwt.* 3 *qr.* 10 *lb.* Having sold at different times to the amount of 5 *T.* 10 *cwt.* 1 *qr.* 20 *lb.*, how much hemp has he still unsold ?

Ans. 4 *T.* 2 *cwt.* 3 *qr.* 18 *lb.*

18. A person who undertook a journey of 900 miles, traveled the first day 39 *m.* 3 *fur.*, the second 40 *m.* 7 *fur.*, the third and fourth each 43 *m.* 6 *fur.* How many miles of his journey then remained to be traveled ? *Ans.* 732 *m.* 2 *fur.*

19. A manufacturer put into one bale 335 *yd.* 3 *qr.* of cotton, into another 400 *yd.*, and into two others each 421 *yd.* 1 *qr.* having sold to one person 100 *yd.* 2 *qr.* from the first bale, and 200 *yd.* from each of the others, how many yards remain ?

Ans. 877 *yd.* 3 *qr.*

20. A gentleman's fortune is estimated at 10000£ sterling. If he give to each of his three sons 2000£, 15 *s.*, and to his only daughter the remainder, what will be the daughter's portion ? *Ans.* 3997£, 15 *s.*

21. A planter has one tract of land containing 3000 *A.*, and two others containing each 1500 *A.* 1 *R.* 16 *P.* If he sell from the first tract 400 *A.* 2 *R.*, and from the other two together 305 *A.* 3 *R.* 25 *P.*, how many acres will remain to him ?

Ans. 5294 *A.* 1 *R.* 7 *P.*

22. A miller bought at one time 200 *bu.* 3 *pk.* of wheat, at another 313 *bu.* 1 *pk.*, and at another 194 *bu.* Having manufactured 405 *bu.* 1 *pk.* of these purchases into flour, what quantity of wheat has he still on hand ? *Ans.* 302 *bu.* 3 *pk.*

23. A grocer bought from one distillery 34 *gal.* 3 *qt.* 1 *pt.* of brandy, from another 40 *gal.*, and from another 31 *gal.* 1 *qt.* Having sold to the amount of 50 *gal.* 1 *qt.* 1 *pt.*, what quantity remains unsold ? *Ans.* 55 *gal.* 3 *qt.*

24. Farmer A has 300 *A.* 1 *R.* 40 *P.* of land; B has 100 *A.* 2 *R.* 13 *P.* more than A, and C has 39 *A.* 10 *P.* more than B, while D has 75 *A.* 2 *R.* 20 *P.* less than the other three together. How much land has B, C, and D, respectively ?

Ans. B, 401 *A.* 13 *P.*; C, 440 *A.* 23 *P.*; D, 1066 *A.* 16 *P.*

Interval of Time between two given Dates.

§ **195.** *In subtracting a prior from a later date*, add to the number of days elapsed in the month of the later date (when requisite,) as many as make the month *of the prior date*, and allow 12 months to a year.

EXAMPLE.

To find the interval between the 20th day of March, 1823, and the 10th day of April, 1848.

y.	*m.*	*da.*
1848	4	10
1823	3	20
25	0	21

March being the 3*d*, and April the 4*th* month in the year, we designate them by these numbers, respectively.

Since March has 31 days, 11 days of it remained after the 20th. Adding these 11 *da.*, to the 10 *da.* of April, we have 21 *da.*; and it is plain that whatever number of months might intervene between the months of *the two given dates*, the surplus days would be found in a similar manner.

But $31-20+10=10+31-20$; hence the 21 *da.* (and the surplus days in every case) will be found, most readily, by the direction above given. (§ 195).

§ **196.** The interval of time, found as above, will include the particular day of the later date, but not that of the prior one.

Thus in the Example given, the 10th of April is included in the interval 25 *y.* 21 *da.*, but not the 20th of March,—as is obvious from the explanation.

25. Find the interval of time between May 16th, 1834, and September 4th, 1848. *Ans.* 14 *y.* 3 *m.* 19 *da.*

26. A person was born on the 3d of April, 1807: required his age on the 15th of December, 1848.
Ans. 41 *y.* 8 *m.* 12 *da.*

27. How long was it from the discovery of America, October 21st, 1492, to the founding of Jamestown, May 23d, 1607?
Ans. 114 *y.* 7 *m.* 2 *da.*

28. How long was the founding of Jamestown prior to the birth of Washington, February 22d, 1732; and what was Washington's age at his death, December 14th, 1799?
Ans 124 *y.* 8 *m.* 30 *da.*, and 67 *y.* 9 *m.* 21 *da.*

MULTIPLICATION OF POLYNOMIALS.

RULE XXXIX.

§ 197. *For Polynomial or Compound Multiplication.*

1. Proceeding from right to left, multiply each term of the polynomial separately, and under each set its product, if less than a unit of the next higher denomination.

2. *If not less than such unit,* divide the product by that number of its own denomination which makes a unit of the next higher; set the remainder, if any, under the term, and add the quotient to the product of the next term.

EXAMPLE.

To multiply 25£, 16 *s.* 3 *d.* by 3.

£,	*s.*	*d.*
25	16	3
		3
77	8	9

Proceeding from right to left, we say 3 times 3 *d.* is 9 *d.*; 3 times 16 *s.* is 48 *s.*, which, being more than 1£, we divide by 20, since 20 *s.* make 1£. Setting down the remainder 8 *s.*, we add the quotient 2 to the product of the next term; 3 times 25 is 75, and 2 makes 77.

The product is thus found to be 77£, 8 *s.* 9 *d.*

This Rule depends on the same principles as the Rule for polynomial or compound addition.

EXERCISES.

1. What should be paid for 4 yards of broadcloth, at 1£, 3 *s.* 8 *d.* per yard? *Ans.* 4£, 14 *s.* 8 *d.*

2. Required the aggregate weight of 5 silver goblets, each weighing 1 *lb.* 9 *oz.* 13 *dwt.*? *Ans.* 9 *lb.* 5 *dwt.*

3 Bought 6 loads of hay, each of which weighed 19 *cwt.* 3 *qr.* 23 *lb.* Required their entire weight. *Ans.* 119 *cwt.* 2 *qr.* 26 *lb.*

4. An apothecary sold 7 bottles of quinine, each weighing 12 *oz.* 13 *dr.* What was the weight of the whole? *Ans.* 5 *lb.* 9 *oz.* 11. *dr.*

5. A farmer filled 23 sacks of corn, each containing 5 *bu.* 3 *pk.* 1 *qt.* What quantity did they all contain?
Ans. 132 *bu.* 3 *pk.* 7 *qt.*

6. A brewer sold to each one of 9 men 18 *gal.* 3 *qt.* 1 *pt.* of beer. What quantity did he sell in all?
Ans. 169 *gal.* 3 *qt.* 1 *pt.*

7. A vintner bought of 10 persons each 3 *hhd.* 24 *gal.* 2 *qt.* of wine. How much did he buy from them all?
Ans. 33 *hhd.* 56 *gal.*

8. If a man travel at the rate of 33 *m.* 7 *fur.* 30 *r.* per day, what number of miles will he travel in 11 *da.*?
Ans. 373 *m.* 5 *fur.* 10 *r.*

9. A merchant sold 19 pieces of linen, each piece containing 16 *yd.* 3 *qr.* 2 *na.* How many yards did he sell?
Ans. 320 *yd.* 2 *qr.* 2 *na.*

10. A farmer has 13 fields, each containing 24 *A.* 3 *R.* 10 *P.* What quantity of land do all the fields contain?
Ans. 322 *A.* 2 *R.* 10 *P.*

11. If a steamboat run at the rate of 12 *m.* 3 *fur.* 19 *r.* per hour, what distance will it run in 14 hours? *Ans.* 174 *m.* 26 *r.*

12. If a ship sail at the rate of 30 *L.* 2 *m.* 4 *fur.* 20 *r.* per day, what distance will she sail in 15 *da.*?
Ans. 462 *L.* 2 *m.* 3 *fur.* 20 *r.*

13. A teamster hauled 16 loads of coal, averaging 2 *T.* 17 *cwt.* 1 *qr.* each. What was the entire weight?
Ans. 45 *T.* 16 *cwt.*

14. A manufacturer made 17 pieces of cloth, measuring 39 *yd.* 3 *qr.* each. How much cloth was there in all?
Ans. 675 *yd.* 3 *qr.*

15. An astronomical year being 365 *da.* 5 *hr.* 48 *min.* 51 *sec.*, required the number of days in 20 such years.
Ans. 20 *y.* 4 *da.* 20 *h.* 17 *min.*

16. An agriculturist had 15 acres of ground in hemp, and found his crop to be at the rate of 7 *cwt.* 3 *qr.* 10 *lb.* per acre; what was the entire crop? *Ans.* 13 *T.* 17 *cwt.* 2 *qr.* 10 *lb.*

17. A brewer filled 3 hogsheads with beer, out of which he has sold to the amount of 75 *gal.* 3 *qt.* 1 *pt.* What quantity remains of the 3 *hhd.*? *Ans.* 1 *hhd.* 32 *gal.* 0 *qt.* 1 *pt.*

18. A merchant bought 7 pieces of silk containing, on an average, 47 *yd.* 2 *qr.* each. Having sold to one lady 11 *yd.*, and to three others each 10 *yd.* 3 *qr.*, how many yards of the silk remain on hand? *Ans.* 289 *yd.* 1 *qr.*

19. A bought of B 100 *A.* 2 *R.* 21 *P.* of land, of C 5 times as much as from B, wanting 10 *A.*, and from D as much as from C, wanting 3 *A.* 2 *R.* 30 *P.* What was the amount of his purchase? *Ans.* 1083 *A.* 1 *R.* 1 *P.*

DIVISION OF POLYNOMIALS.

RULE XL.

§ **198.** *For Polynomial or Compound Division.*

1. *When the divisor is an abstract number, and the dividend a polynomial.*—Proceeding from left to right, divide each term of the polynomial, for the corresponding term of the quotient.

2. *When a remainder occurs,* reduce it to the next lower denomination, add it to the term in that denomination, if any, and divide the result for the quotient term in the same denomination.

3. *When the divisor and dividend are both polynomials.*—Reduce them both to monomials of the same denomination, and find the quotient in an abstract number.

EXAMPLE.

To divide 285£, 17 *s.* 5 *d.* by 3; that is to find $\frac{1}{3}$ of this polynomial.

$$\begin{array}{rrrrl} & \text{£,} & s. & d. & \\ 3) & 285 & 17 & 5 & \\ \hline & 95 & 5 & 9 & 2\frac{2}{3}\,qr. \end{array}$$

Proceeding from left to right, we find 3 in 285, 95 times; 3 in 17, 5 times, with 2 *s.* over; reducing the 2 *s.* to *pence*, and adding the 5 *d.*, we have 29 *d.*; then 3 in 29, 9 times, with 2 *d.* over; reducing the 2 *d.* to *qr.*, we have 8 *qr.*; 3 in 8, gives $2\frac{2}{3}$ *qr.*

The quotient is thus found to be 95£, 5 *s.* 9 *d.* $2\frac{2}{3}$ *qr.*

The operation evidently finds $\frac{1}{3}$ of the given polynomial.

EXERCISES.

1. If 4 yards of cloth sell for 9£, 17 *s.* 8 *d.*, what is the price per yard? *Ans.* 2£, 9 *s.* 5 *d.*

2. If 5 silver candlesticks weigh 10 *lb.* 7 *oz.* 18 *dwt.*, what is the average weight of each? *Ans.* 2 *lb.* 1 *oz.* $11\frac{3}{5}$ *dwt.*

3. If 6 barrels of pork weigh 12 *cwt.* 2 *qr.* 23 *lb.*, what is the average weight of each? *Ans.* 2 *cwt.* 0 *qr.* $13\frac{1}{6}$ *lb.*

4. If 7 acres of ground produce 150 *bu.* 2 *pk.* 1 *qt.* of wheat, what is the produce per acre? *Ans.* 21 *bu.* 2 *pk.* $\frac{1}{7}$ *qt.*

5. If 8 casks together contain 250 *gal.* 3 *qt.* 1 *pt.* of spirits, what are the average contents of each? *Ans.* 31 *gal.* 1 *qt.* $3\frac{1}{2}$ *gi.*

6. If a person travel 300 *m.* 2 *fur.* 25 *p.* in 9 days, at what rate will he travel per day? *Ans.* 33 *m.* 2 *fur.* $38\frac{1}{3}$ *p.*

7. A merchant has 10 pieces of cloth, of equal length, and together containing 575 *yd.* 2 *qr.* 3 *na.* What is the length of each piece? *Ans.* 57 *yd.* 2 *qr.* $1\frac{1}{10}$ *na.*

8. A farmer having a tract of land containing 486 *A.* 2 *R.* 30 *P.*, wishes to divide it into 12 fields of equal size. What quantity must there be in each field? *Ans.* 40 *A.* 2 *R.* $9\frac{1}{6}$ *P.*

9. A cellar measuring 1570 *cu. yd.* 18 *cu. ft.* was excavated by a man in 30 days. At what rate did he dig per day?
Ans. 52 *cu. yd.* $9\frac{3}{5}$ *cu. ft.*

10. A manufacturer sold 13 pieces of cotton cloth, measuring in the aggregate 500 *yd.* 3 *qr.* Required the average length of each piece. *Ans.* 38 *yd.* $2\frac{1}{13}$ *qr.*

When the divisor and dividend are both Polynomials.

11. How many yards of silk at 7 *s.* 6 *d.* per yard may be purchased for 3£, 14 *s.* 10 *d.*?

The number of yards is the number of times that 7 *s.* 6 *d.* is contained in 3£, 14 *s.* 10 *d.*

Applying the 2d part of the Rule, we find,

7 *s.* 6 *d.*=90 *d.*; and £3, 14 *s.* 10 *d.*=898 *d.*;

90 *d.* is contained in 898 *d.*, 9.977' times. *Ans.* 9.977' *yd.*

12. How many hundred weight of iron, at 19 *s.* 8 *d.* per *cwt.* may be bought for 20£, 15 *s.*? *Ans.* 21.101' *cwt.*

13. How many acres of ground can be sown with 75 *bu.* 1 *pk.* of wheat, allowing 1 *bu.* 3 *pk.* to an acre? *Ans.* 43 *A.*

14. In what time will a ship perform a voyage of 1000 *L.* 2 *m.*, if she sail at the rate of 60 *L.* 1 *m.* per day?
Ans. 16.585' *da.*

15. What number of carpets, each to contain 34 *yd.* 3 *qr.*, can be made out of 2 pieces of carpeting, each measuring 50 *yd.*, and another piece measuring 49 *yd.* 2 *qr.*?
Ans. 4.302' *carpets.*

16. A silversmith makes 6 *lb.* 7 *oz.* 4 *dwt.* of silver into spoons weighing 3 *oz.* 6 *dwt.*, each, and sells the spoons at 3 *s.* 6 *d.* apiece. What does he get for his spoons? *Ans.* 4£, 4 *s.*

17. A sugar planter makes 113 *T.* 9 *cwt.* 2 *qr.* of sugar, which is to be put into hogsheads that will contain, on an average, 12 *cwt.* 2 *qr.* How many such hogsheads will be requisite?
Ans. 181.56 *hhd.*

18. A traveler performed a journey of 975 *m.* 7 *fur.* The first 20 days he traveled 31 *m.* 2 *fur.* per day, and during the remainder of the journey 29 *m.* 5 *fur.* per day. How long was he on the journey? *Ans.* 31.843' *da.*

DUODECIMALS,

AND THEIR APPLICATION TO SQUARE AND CUBIC MEASURE.

§ 199. DUODECIMALS are a kind of polynomial quantities which result from supposing a *linear*, *square*, or *cubic foot*, to be divided into 12 *equal parts*, each of these parts again into 12 equal parts ; and so on.

12*ths* of a *foot* are called *primes ;*
12*ths* of a prime are called *seconds ;*
12*ths* of a second are called *thirds ;* and so on.

Primes are denoted by an *index* of *one accent;* thus, 3′, 3 *primes.*

Seconds are denoted by an index of two accents ; thus 4″, 4 seconds.

Thirds are denoted by an index of three accents ; thus, 7‴, 7 thirds, &c.,

The polynomial 8 *ft.* 2′ 5″ 7‴, for example, is 8 *feet*, 2 *primes*, 5 *seconds*, and 7 *thirds.*

How many *fourths* make one *third ?* How many thirds make 1 *second ?* How many seconds make one *prime ?* How many primes make 1 *foot ?*

Linear, Square, and Cubic Inches expressed in Duodecimals.

§ 200. In *linear* measure, it is plain that *inches* are *primes.*

Thus 3 *ft.* 4 *in.* is 3 *ft.* 4′, 3 *ft.* and 4 *primes.*

§ 201. In *square* measure, square inches are *seconds.*

For 1 *square inch* is $\frac{1}{144}$ of a square foot, since 144 *sq. in.* = 1 *sq. ft.*; and $\frac{1}{144}$ of a *sq. ft.* is 1″ or $\frac{1}{12}$ of $\frac{1}{12}$ of a square foot.

§ 202. In *cubic* measure, cubic inches are *thirds.*

For 1 cubic inch is $\frac{1}{1728}$ of a cubic foot, since 1728 *cu. in.* = 1 *cu. ft.*; and $\frac{1}{1728}$ of a *cu. ft.* is 1‴ or $\frac{1}{12}$ of $\frac{1}{12}$ of $\frac{1}{12}$ of a cubic foot.

In 7′, *linear* measure, how many inches? In 9′? In 5′? In 11′? In 5′, *square* measure, how many *sq.* inches? In 7′? In 8′ 3″? In 6′, *cubic* measure, how many *cu.* inches? In 4′? In 7′ 2″?

Square and Cubic Measure—how found.

§ **203.** Square measure, or measure of *surface*, is found by multiplying together *length* and *breadth*.

For example, 4 *in.* long and 3 *in.* wide, makes (4×3) 12 *sq. inches.*

§ **204.** Cubic measure, or measure of *solidity*, is found by multiplying together *length*, *breadth*, and *thickness*.

For example, 4 *in.* long, 3 *in.* wide, and 2 *in.* thick, makes (4×3×2) 24 *cubic inches.*

Product of two Duodecimal Terms.

§ **205.** The product of any two terms in duodecimals, has for its *index* the sum of the *indices* of the two terms ;—a term in *feet* being understood to have *no index.*

For example, take 3 *ft.* in length, and 2′ in breadth.

$$3\,ft.\times 2'=3\,ft.\times \tfrac{2}{12}\,ft.=\tfrac{6}{12}\,sq.\,ft.\ (\S\ 203),=6'\,sq.\,ft.$$

Again ; taking 3′ in length, and 2″ in breadth.

$$3'\times 2''=\tfrac{3}{12}\,ft.\times \tfrac{2}{144}\,ft.=\tfrac{6}{1728}\,sq.\,ft.\ (\S\ 203),=6'''\,sq.\,ft.$$

In these examples, the products 6′ and 6‴ have their *indices* (′ and ‴) equal, respectively, to the *sums* of *the indices* of the two terms multiplied together.

Reduction, Addition, &c., of Duodecimals.

§ **206.** Reduction, Addition, &c., are performed in Duodecimals in the same manner as in other polynomials.

We have here, however, a distinct case—that of multiplying one duodecimal polynomial by another—from the manner of performing it, sometimes called *Cross Multiplication.*

RULE XLI.

§ **207.** *For Duodecimal or Cross Multiplication.*

1. Multiply each term of the multiplicand, from right to left, by each term of the multiplier, noting the denomination of each product term, by means of indices (§ 205), and setting similar terms one under another.

2. When any product term (excepting *ft.*) is 12 or more, divide it by 12 ; set down the remainder, if any, and add the quotient to the product of the next term.

3. Add up the similar product terms, as in polynomial addition, for the entire product.

EXAMPLE.

To find the number of square feet in a plank 16*ft.* 8 *in.* long, and 2*ft.* 5 *in.* wide.

$$\begin{array}{lll} \textit{ft.} & {}' & \\ 16 & 8 & \\ 2 & 5 & \\ \hline 6 & 11' & 4'' \\ 33 & 4' & \\ \hline 40\,\textit{sq. ft.} & 3' & 4'' \end{array}$$

Denoting *inches* or *primes*, by an index ′, and multiplying, we have $8'\times5'=40''$, the product 40 having an index ″ equal to the sum of the indices of the two terms 8′ and 5′, (§ 205.)

Dividing the 40″ by 12, since 12″ make 1′, we get 3′ and 4″. We set the 4″ towards the right; and then multiplying the 16*ft.*, we find 16*ft.*×5′=80′; adding the 3′, we have 83′; dividing by 12, we get 6*ft.* and 11′, which we set in the places of *ft.* and primes, respectively.

Next, 8′×2*ft.* =16′=1*ft.* 4′; setting the 4′ under 11′, and adding the 1*ft.* to 16*ft.* ×2*ft.*, we find 33*ft.*

The two rows of products are added together, for the entire product. We thus find 40 *sq. ft.* 3′ 4″. And since, in square measure, *seconds* are *square inches*, (§ 201), by reducing the 3′ to *seconds*,

we find $3'\times12+4''=40''$ or 40 *sq. in.*

Without employing duodecimals,—

16*ft.* 8 *in.*=$16\frac{8}{12}$*ft.*, and 2*ft.* 5 *in.* =$2\frac{5}{12}$*ft.*;

then $16\frac{8}{12}\times2\frac{5}{12}=40\frac{5}{18}$ *sq. ft.* =40 *sq. ft.* and 40 sq. inches.

Or, 16*ft.* 8 *in.* =16.666'*ft.*, and 2*ft.* 5 *in.* =2.416'*ft.*;

then 16.666'×2.416'=40.265056' *sq. ft.* =40 *sq. ft.* 38.168' *sq. in.*; the number of square inches falling a little below the true number 40, by reason of the imperfect decimals .666' and .416'.

If the 16*ft.* 8 *in.*, and 2*ft.* 5 *in.* were reduced to *inches*, and then multiplied together, we should find the product in *square inches*, which, divided by 144, would be reduced to *square feet.*

The measure of a surface, as expressed in *sq. in.*, *sq. ft.*, &c., is called its *area.* Thus the area of the plank in the preceding example, is 40 *sq. ft.* 3′ 4″, or 40 *sq. ft.* 40 *sq. in.*

EXERCISES.

1. How many square feet are there in a pavement 30 *ft.* 10 *in.* long, and 7 *ft.* 5 *in.* wide? *Ans.* 228 *sq. ft.* 8′ 2″.

2. How many square feet of plank will make a close fence 80 *ft.* 8 *in.* long, and 6 *ft.* 4 *in.* high? *Ans.* 510 *sq. ft.* 10′ 8″.

3. How many square feet, and also how many square yards are in a ceiling 18 *ft.* 5 *in.* long, and 12 *ft.* 10 *in.* wide?
Ans. 236 *sq. ft.* 50 *sq. in.*=26 *sq. yd.* 2 *ft.* 50 *in.*

4. How many square yards are contained in a floor which measures 25 *ft.* in length, and 16 *ft.* 7 *in.* in breadth?
Ans. 46 *sq. yd.* 84 *sq. in.*

5. How many square yards of plastering would be required for one side of a wall which is 50 *ft.* 6 *in.* in length, and 20 *ft.* 4 *in.* in height? *Ans.* 114 *sq. yd.* 120 *sq. in.*

6. Required the number of *cubic feet* in a piece of timber 9 *ft.* 10 *in.* long, 3 *ft.* 4 *in.* wide, and 2 *ft.* 6 *in.* thick.

Multiplying the length and breadth together, we get the product 32 *sq. ft.* 9′ 4″.

Multiplying this product by the thickness, we get the product 81 *cu. ft.* 11′ 4″ for the solidity.

Since, in cubic measure, *thirds* are *cubic inches*, by reducing the 11′ 4″ to *thirds*, $11' \times 12 + 4'' = 136''$, and $136'' \times 12 = 1632''' = 1632$ *cu. in.*

Without employing duodecimals, the given dimensions might be taken in *feet* and *fractions* of a foot. Or the dimensions might all be reduced to *inches*, and the final product divided by 1728, since 1728 *cu. in.* make 1 *cu. ft.*

7. How many cubic feet are there in a hewn log 22 *ft.* 8 *in.* long, 1 *ft.* 10 *in.* wide, and 1 *ft.* 2 *in.* thick?
Ans. 48 *cu. ft.* 5′ 9″ 4‴.

8. How many cubic feet are there in a piece of scantling 15 *ft.* long, 1 *ft.* 2 *in.* wide, and 8 inches thick?
Ans. 11 *cu. ft.* 8′.

9. How many cubic feet were dug from a cellar which measures 42 *ft.* 10 *in.* long, 12 *ft.* 6 *in.* wide, and 8 feet deep? How many cubic yards?
Ans. 4283 *cu. ft.* 4′=158 *cu. yd.* 17 *cu. ft.* 4′.

10. It is required to find how many cubic yards of earth were excavated from a ditch which measures 100 *ft.* in length, 4 *ft.* 8 *in.* in breadth, and 3 *ft.* in depth.
Ans. 51 *cu. yd.* 23 *cu. ft.*

EXERCISES ON CHAPTER VIII.

1. A farmer sold at one time $2\frac{1}{4}$ *cwt.*, at another $3\frac{1}{2}$ *qr.*, and at another $18\frac{3}{4}$ *cwt.* of hemp. Find the entire quantity that he sold, in *cwt.* *Ans.* $21\frac{7}{8}$ *cwt.*

2. A grocer bought, at different times, $3\frac{1}{5}$ *cwt.*, $2\frac{1}{4}$ *qr.* and 49 *lb.* of soap; of which he has sold 2 *cwt.* 1 *qr.* Find the quantity remaining, in *lb.* *Ans.* $218\frac{2}{5}$ *lb.*

3. A merchant had 3 pieces of cloth, containing each 29 *yd.* 3 *qr.*; of which he has sold, to different persons, $5\frac{1}{8}$ *yd.*, $3\frac{1}{2}$ *qr.*, and 10 *yd.* $1\frac{1}{2}$ *qr.* Find the remainder in *yd.* *Ans.* $72\frac{7}{8}$ *yd.*

4. A brewer bought of A 13 *bu.* 3 *pk.*, of B $5\frac{3}{4}$ *bu.*, and of C 11 *bu.* 1 *pk.* $1\frac{1}{2}$ *qt.* of barley. Having consumed $9\frac{1}{4}$ *bu.*, $3\frac{1}{2}$ *pk.*, and $5\frac{3}{4}$ *bu.*, how many *bu.* has he on hand? *Ans.* $14\frac{59}{64}$ *bu.*

5. How many yards of cloth, at 30 *s.* per yard, may be purchased for 9£; and what quantity of iron, at 6£ per ton, may be purchased for 40 *s.*? *Ans.* 6 *yd.*; and $\frac{1}{3}$ of a ton.

6. How many days will a ship be in sailing 750 *L.*, at the rate of $10\frac{1}{2}$ miles per hour; and to what part of a common year will the time required be equivalent?
Ans. $8\frac{13}{14}$ *da.*; $\frac{25}{1022}$ of a *y.*

7. A wine merchant has in one cask 74 *gal.* 3 *qt.*, and in two others each 60 *gal.* 2 *qt.* 1 *pt.*, of wine. What quantity has he altogether? *Ans.* 196 *gal.*

8. A traveler who set out on a journey of 600 *m.* 5 *fur.*, proceeded for 12 days at the rate of 34 *m.* 2 *fur.* 20 *rd.* per day. What distance remained to be traveled? *Ans.* 188 *m.* 7 *fur.*

9. A merchant has 5 pieces of cotton, containing 33 *yd.* 3 *qr.* each; which he sold in equal portions to ten customers. What quantity was bought by each customer?
Ans. 16 *yd.* $3\frac{1}{2}$ *qr.*

10. A planter has a tract of land containing 1250 *A.* 3 *R.* 25 *P.*, and an adjoining one containing 2400 *A.* 1 *R.* 39 *P.* If the whole be divided into 10 plantations, what will be the average size of each? *Ans.* 365 *A.* 0 *R.* $22\frac{2}{5}$ *P.*

11. A stage coach is running at the rate of 7 *m.* 3 *fur.* 30 *rd.* per hour. How long will it be in running 75 *m.* 7 *fur.*?
Ans. 10.158' *hr.*

12. An agriculturist raised 500 *bu.* 3 *pk.* 4 *qt.* of oats from one field, and he found the produce to be at the rate of 29 *bu.* 1 *pk.* 1 *qt.* per acre. How many acres did the field contain?
Ans. 17.105' *A.*

13. From a tract of land containing 560 *A.* 2 *R.* 20 *P.*, a farmer sold to one of his neighbors 7 *A.* 3 *R.*, and to another 100 *A.* 25 *P.* What part of the tract did he sell to each?
Ans. .0138'; and .178'.

14. How many yards of carpeting, one yard in width, will be required to cover the floor of a room measuring 19 *ft.* 5 *in.* long, and 10 *ft.* 6 *in.* wide? *Ans.* 22.652' *yd.*

15. How many cords of wood are there in a pile which is 19 *ft.* 10 *in.* in length, 4 *ft.* in breadth, and 3 *ft.* 11 *in.* in height, —there being 128 cubic feet in a cord? *Ans.* 2.427' cords.

16. How many cords of wood in five loads each 8 *ft.* 10 *in.* in length, 3 *ft.* 6 *in.* wide, and 3 *ft.* 4 *in.* high? *Ans.* 4.025' cords.

17. How many square yards of painting on the walls of a room measuring 11 *ft.* in height, and 52 *ft.* 6 *in.* in compass,— deducting four windows each 7 *ft.* by 5 *ft.* 2 *in.*? *Ans.* 48.092' *sq. yd.*

18. Bought a load of wood which measured 6 *ft.* 4 *in.*, 3 *ft.* 3 *in.*, and 2 *ft.* 10 *in.*; another measuring 7 *ft.*, 3 *ft.* 11 *in.*, and 3 *ft.*; and another measuring 8 *ft.*, 4 *ft.*, and 3 *ft.* Required the number of cords purchased. *Ans.* 1.849' cords

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REMARKS.

The last two Chapters, it may be remarked, contain but little more than an *application* of the essential principles of Arithmetic, to the various *arbitrary measures of quantities* which have been established in the commerce of society.

Facility of operation on such quantities will depend very much on a familiarity with the *Tables of Weights* and *Measures*—of which, with the several Rules in these Chapters, the student should be master, before he is permitted to advance.

CHAPTER IX.

ALIQUOT PARTS—ANALYSIS—CANCELLATION—RATIO—PROPORTION.

ALIQUOT PARTS.

§ 208. An *aliquot part* of a quantity is an exact *half*, *third*, or *fourth*, and so on, of the quantity.

Thus 10 *s*. is an aliquot part of 1£, being ½ of 1£.

What aliquot part is 6 *gr*. of 1 *dwt*.? 5 *dwt*. of 1 *oz*.? Of 2 *oz*.?
What aliquot part is 7 *lb*. of 1 *qr*.? 2 *qr*. of 1 *cwt*.? Of 3 *cwt*.?
What aliquot part is 2 *qt*. of 1 *gal*.? 1 *qt*. of 1 *pk*.? Of 3 *pk*.?
What aliquot part is 8 *rd*. of 1 *fur*.? 2 *fur*. of 1 *m*.? Of 4 *m*.?
What aliquot part is 10 *P*. of 1 *R*.? 2 *R*. of 1 A.? Of 5 *A*.?

It is often convenient to regard the lower orders of units in a *polynomial multiplier*, as aliquot parts of one or more higher units.

ANALYSIS.

§ 209. ANALYSIS, in Arithmetic, consists in determining the operations to be performed in the solution of questions, without the aid of special Rules.

EXAMPLE

Of Analysis by Aliquot Parts.

To find the value of 2 *lb*. 5 *oz*. 12 *dwt*. of silver ware, at $45.12½ per *lb*.

We first find the value of 2 *lb*., *by multiplying, and then of* 5 *oz*. 12 *dwt*. *by taking* aliquot parts, *as folows :*

		$45.125	
		2	
The value of 2 *lb*.	is	90.250,	*twice* the value of 1 *lb*.
" " of 4 *oz*.	is	15.0416,	⅓ of " " of 1 *lb*.
" " of 1 *oz*.	is	3.7604,	¼ of " " of 4 *oz*.
" " of 10 *dwt*.	is	1.8802,	½ of " " of 1 *oz*.
" " of 2 *dwt*.	is	.3760,	⅕ of " " of 10 *dwt*.
		$111.3082,	*value of the whole.*

The values of the several parts, 2 *lb.*, 4 *oz.*, 1 *oz.*, 10 *dwt.*, 2 *dwt.* added together, make the value of the whole quantity 2 *lb.* 5 *oz.* 12 *dwt.*

For convenience in dividing, the aliquot parts should be apportioned, when practicable, so that no divisor, exclusive of 0s annexed, shall exceed 12.

EXERCISES

In Analysis by Aliquot Parts.

1. Find the value of 3 *lb.* 4 *oz.* 17 *dwt.*, of jewelry, at $50.50 per *lb.*

After multiplying the given price by 3, *aliquot parts may be* taken thus: 4 *oz.* is ⅓ of 1 *lb.*, 10 *dwt.* is ⅛ of 4 *oz.*, 5 *dwt.* is ½ of 10 *dwt.*, and 2 *dwt.* is ⅕ of 10 *dwt.* *Ans.* $171.909'.

2. Find the sum that should be paid for 3 *T.* 10 *cwt.* 3 *qr.* of iron, at $30.37½ per ton. *Ans.* $107.45'.

3. Find the sum that should be paid for 13 *cwt.* 2 *qr.* 15 *lb.* of soap, at $3.62½ per *cwt.* *Ans.* $49.422'.

4. A farmer sold 125 *bu.* 3 *pk.* 1 *qt.* of wheat, at $0.87½ per bushel. What did the whole amount to? *Ans.* $110.058'.

5. A market man sold 3 *pk.* 3 *qt.* of cherries, at $0.18¾ per peck. What did his cherries amount to? *Ans.* $0.632'.

6. A merchant sold 15 *yd.* 3 *qr.* 3 *na.* of silk, at $1.37½ per yard, and 5 *yd.* 2 *qr.* of lace, at $2.50 per yard. What did the whole amount to? *Ans.* $35.661'.

7. Find what would be the amount of profit or loss on 139 *yd.* 2½ *qr.* of cloth, if purchased at $5 a yard, and sold at the rate of $1.56¼ per *qr.* *Ans.* $174.531' profit.

8. A townsman bought a lot of ground containing 3 *A.* 2 *R.* 25 *P.*, at $75 per acre. What did he pay for the lot? *Ans.* $274.218'.

9. Find what would be the expense of putting up 150 *rd.* 4 *yd.* of fencing, at $.50 per rod, and 230 *rd.* 2½ *yd.* of another kind at the rate of 62½ *cts.* per rod. *Ans.* $219.397 .

10. A speculator purchased 15 *A.* 2 *R.* 30 *P.* of land, at $5 per acre, which he divided into town lots, and sold at the rate of $20 per rood or quarter acre. What did he gain by the speculation? *Ans.* $1176.563'.

CANCELLATION.

§ **210.** CANCELLATION, in Arithmetic, consists in *rejecting equal factors* from a dividend and its divisor;—which is equivalent to dividing the dividend and divisor by the same number (§ 69), and therefore does not alter the *required quotient*. (§ 57).

§ **211.** In the Analysis of questions, the given numbers may often be put as factors in a dividend and divisor, and *cancellation* then applied.

EXAMPLE

Of Analysis and Cancellation.

Allowing $\frac{3}{4}$ of a yard of cloth to cost $10, what will $\frac{5}{8}$ of a yard cost at the same rate?

Analysis. Since 3 *fourths* of a *yd.* costs $10,

1 *fourth* of a *yd.* will cost $\frac{1}{3}$ of $10, which is $\frac{\$10}{3}$;

and 1 *yd.* will cost 4 times as much as $\frac{1}{4}$ *yd.*, $\frac{\$10\times4}{3}$.

Again; $\frac{1}{8}$ *yd.* will cost $\frac{1}{8}$ as much as 1 *yd.* will, $\frac{\$10\times4}{3\times8}$,

and $\frac{5}{8}$ *yd.* will cost 5 times as much as $\frac{1}{8}$ *yd.*, $\frac{\$10\times4\times5}{3\times8}$.

Cancellation. Dividing the numerator and denominator, in other words, the dividend and divisor, both by 4, we have $\frac{\$10\times5}{3\times2}$;

dividing these again by 2, we have $\frac{\$5\times5}{3}=\frac{\$25}{3}=\$8\frac{1}{3}$.

If the factors of the dividend be set, *one under another*, on the right of a line, and those of the divisor on the left, the sign of multiplication may be omitted. In canceling, the rejected factors may be *crossed*, and those to be substituted set respectively right and left.

By this method the result of the preceding Analysis and Cancellation, will be presented thus:

$$\begin{array}{rrr|ll} & & & \cancel{10} & 5 \\ & & 3 & \cancel{4} & 1 \\ 1 & \cancel{2} & \cancel{8} & 5 & \end{array} \qquad \textit{Result } \frac{5\times5}{3}=8\tfrac{1}{3}.$$

Canceling 4 and 8, we substitute 1 and 2; canceling 2 and 10, we substitute 1 and 5. The factor 1 is omitted in multiplying.

But observe that ***when each factor of the dividend becomes* 1**, the 1 must be retained **as the *numerator of a fraction.***

EXERCISES

In Analysis and Cancellation.

1. Allowing $\frac{2}{3}$ of a yard of cloth to cost $6, what should be paid for $\frac{1}{4}$ of a yard at the same rate? *Ans.* $$2\frac{1}{4}$.

2. If 5 men can accomplish a certain work in 20.5 days, in what time ought 25 men to perform 3.5 times as much work? *Ans.* 14.35 days.

3. What should be paid for $\frac{3}{8}$ of a ton of hay, when $2\frac{1}{4}$ tons of the same amount to $18? *Ans.* $3.00.

4. Allowing a person to walk $\frac{7}{8}$ of a mile in 12 minutes, what distance would he walk in 40 minutes? *Ans.* $2\frac{11}{12}$ miles.

5. If $\frac{1}{2}$ of $\frac{3}{4}$ of an acre of ground be worth $16, what is the value of $2\frac{1}{2}$ acres at the same rate? *Ans.* $$106\frac{2}{3}$.

6. A teamster hauled 25 *cwt.* of iron 30.5 miles for a certain sum of money. How far then ought he to haul 6.5 *cwt.* for the same sum? *Ans.* 117.307 miles.

7. How long ought 20 men to subsist on a stock of provisions which would suffice 18 men for 300 days? *Ans.* 270 days.

8. A person who owned $\frac{1}{4}$ of a merchant ship, sold $\frac{2}{5}$ of his share for $400; what was the whole ship worth at that rate? *Ans.* $4000.

9. Allowing a person to perform $\frac{2}{3}$ of a certain work in $\frac{3}{8}$ of a day, in what time ought he to perform the entire work? *Ans.* $\frac{9}{16}$ day.

10. The distance from A to B, which is 40 miles, is $\frac{4}{5}$ of the distance from B to C: how far then is it from B to C? *Ans.* 50 miles.

11. If $\frac{2}{3}$ of $\frac{3}{8}$ of a yard of cloth be worth $1.25, what is $\frac{1}{2}$ of $\frac{5}{6}$ of a yard worth, at the same rate? *Ans.* $2.083'.

12. A contributed towards building a church $200, which was $\frac{7}{8}$ of the sum contributed by B, who gave $\frac{2}{5}$ as much as C. What was the amount of C's contribution? *Ans.* $$571\frac{3}{7}$.

13. If 4.5 cords of wood sell for $13.5, what should be given for 5 loads, each containing 1.25 cords? *Ans.* $18.75.

14. Allowing 3 bushels of wheat to be worth as much as $6\frac{1}{4}$ bushels of corn, how many bushels of corn are equal in value to $12\frac{1}{2}$ bushels of wheat? *Ans.* $26\frac{1}{24}$ *bu.*

15. A has $\frac{3}{4}$ as much money as B, and $\frac{4}{5}$ as much as C, who has $\frac{5}{6}$ as much as D, and he has $1800. What sums are owned by A, B, and C, respectively? *Ans.* A, $1200; B, $1600; C, $1500.

RATIO.

§ **212.** The *Ratio* of one number or quantity, called the *antecedent*, to another of the same kind, called the *consequent*, is the *quotient* of the former divided by the latter.

Thus the ratio of 15 to 5 is 3, since 15 contains 5, 3 *times;* and the ratio of 4 to 9 is $\frac{4}{9}$, since 4 is $\frac{4}{9}$ of 9.

In these examples 15 and 4 are the *antecedents;* 5 and 9 the *consequents.*

The antecedent and consequent together are called the *terms* of the ratio.

What is the ratio of 12 to 3? Which is the *antecedent*, and which the consequent? Of 3 to 12? Of 20 to 4? Of 5 to 30?

What is the ratio of 10 miles to 5 miles? Of 3 yards to 6 yards? Of 6 hours to 13 hours? Of 25 pounds to 8 pounds? Of 9 *s.* to 20 *s.*?

Ratio of Monomials and Polynomials.

§ **213.** To find the ratio between two quantities, the antecedent and consequent must be in the *same denomination.*

Thus the ratio of 2 *ft.* to 5 *yd.* is the ratio of 2 *ft.* to 15 *ft.* $=\frac{2}{15}$.

What is the ratio of 3 *in.* to 2 *ft.*? Of 4 *yd.* to 6 *ft.*? Of 2 *hr.* to 1 *da.*? Of 10 *s.* to 2£. 10 *s.*? Of 5 *m.* to 3 *L.* 3 *m.*? Of 1 *A.* 2 *R.* to 5 *A.* 4 *R.*?

Two quantities of *different kinds*, that is, such that one can form no *part of the other*, have *no ratio to each other;* as 2 *ft.* and 5 *hours.*

Sign of Ratio.

§ **214.** A *colon* (:) placed between two numbers, signifies that the numbers are taken as the *antecedent* and *consequent* of a ratio.

Thus 3 : 5 signifies the ratio of 3 to 5.

Ratio is also expressed by making the antecedent the *numerator*, and the consequent the *denominator*, of a fraction; thus 3 : 5 is $\frac{3}{5}$.

What fraction expresses the ratio of 3 to 13? Of 25 to 17? Of 4 to 19? Of 21 to 7? Of 3 *quarters* to 7 *yd.* 3 *qr.*?

What fraction expresses the ratio of 5 to 17? Of 4 to 19? Of 5 to 25? Of 7 to 100? Of 5 *bushels* to 7 *bu.* 3 *pk.*

Direct and Inverse Ratio.

§ 215. The *direct* ratio of the *first* of two quantities to the *second*, is the quotient of the first divided by the second.

The *inverse* ratio of the first to the second, is the same as the direct ratio of the *second to the first.*

For example, the *direct* ratio of 6 to 3 is $\frac{6}{3}=2$; the *inverse* ratio of 6 to 3 is the direct ratio 3 to $6=\frac{3}{6}=\frac{1}{2}$.

What is the direct ratio of 8 to 2? Of 3 to 15? Of 10 to 4?
What is the inverse ratio of 9 to 3? Of 5 to 20? Of 21 to 7?
What is the inverse ratio of 4 to 16? Of 25 to 5? Of 9 to 90?

Ratio of Reciprocals.

§ 216. The *inverse* ratio of the *first* of two quantities to the *second*, is equal to the direct ratio of the *reciprocals* of those quantities.

Thus, the inverse ratio of 6 to 3 is $\frac{3}{6}=\frac{1}{2}$;

and the direct ratio of the reciprocals $\frac{1}{6}$ and $\frac{1}{3}$ is $\frac{1}{6}\div\frac{1}{3}=\frac{3}{6}=\frac{1}{2}$.

The *inverse* ratio of 4 to 2 equals the *direct* ratio of what fractions? Of 3 to 5? Of 4 to 9? Of $\frac{2}{3}$ to $\frac{3}{4}$? Of $\frac{3}{5}$ to $\frac{6}{7}$? Of $\frac{3}{8}$ to 10?

The inverse ratio of 3 to 8 equals the direct ratio of what fractions? Of 5 to 7? Of 11 to 4? Of $\frac{1}{4}$ to $\frac{5}{7}$? Of $\frac{3}{7}$ to $\frac{5}{12}$? Of $\frac{4}{9}$ to $\frac{3}{16}$?

Hence *inverse* is sometimes called *reciprocal* ratio. The term ratio, when used alone, always means *direct* ratio.

Ratio of Fractions having a Common Term.

§ 217. The ratio of two fractions having a *common denominator*, is the same as the ratio of their *numerators;* and

The ratio of two fractions having a *common numerator*, is the same as the *inverse ratio* of their *denominators.*

Thus, the ratio of $\frac{4}{15}$ to $\frac{2}{15}=\frac{4}{15}\div\frac{2}{15}=\frac{4}{2}=2$, which is the ratio of the numerators 4 and 2.

And the ratio of $\frac{3}{8}$ to $\frac{3}{16}=\frac{3}{8}\div\frac{3}{16}=\frac{16}{8}=2$, which is the inverse ratio of the denominators 8 and 16.

The ratio of $\frac{3}{7}$ to $\frac{4}{7}$ is equal to the ratio of what *integral* numbers? Of $\frac{13}{12}$ to $\frac{5}{12}$? Of $\frac{7}{16}$ to $\frac{15}{16}$? Of $\frac{20}{27}$ to $\frac{13}{27}$? Of $\frac{31}{60}$ to $\frac{29}{60}$?

The ratio of $\frac{3}{7}$ to $\frac{3}{13}$ is equal to the ratio of what integral numbers? Of $\frac{5}{8}$ to $\frac{5}{20}$? Of $\frac{9}{13}$ to $\frac{9}{25}$? Of $\frac{13}{17}$ to $\frac{13}{19}$? Of $\frac{20}{41}$ to $\frac{20}{53}$?

PROPORTION.

§ **218.** PROPORTION consists in an *equality of ratios.*

Four quantities are in proportion, when the *first* has the same ratio to the *second*, that the *third* has to the *fourth.*

Thus, the numbers 6, 3, 8, 4, are in *proportion;* since the ratio of 6 to 3 is $\frac{6}{3}=2$, and the ratio of 8 to 4 is $\frac{8}{4}=2$.

The *first* and *third* terms, 6 and 8, are the *antecedents* of the ratios; the second and fourth are the *consequents.*

The *first* and *fourth* terms are called the two *extremes;* the second and third, the two *means.*

The *fourth* term is called a *fourth proportional* to the other three taken in order; thus, 4 is a fourth proportional to 6, 3, and 8.

What is the *fourth proportional* to 9, 3, and 12; that is, the number to which 12 has the same ratio that 9 has to 3?

Which are the *antecedents*, and which the consequents? Which are the *extremes*, and which the means?

What is the *4th proportional* to 16, 4, and 20? To 4, 8, and 10?
To 3, 6, and 8? To 4, 12, and 10? To 5, 20, and 12?
To 2, 1, and 10? To 2, $\frac{1}{2}$, and 4? To $\frac{1}{2}$, 1, and $2\frac{1}{2}$?

Direct and Inverse Proportion.

§ **219.** A *direct proportion* consists in an equality between two *direct ratios.* An *inverse* or *reciprocal* proportion consists in an equality between a *direct* and an *inverse* ratio. (§ 215).

Thus, the numbers 6, 3, 8, 4, are in *direct* proportion, since the direct ratio $\frac{6}{3}$ of 6 to 3 is equal to the direct ratio $\frac{8}{4}$ of 8 to 4.

The same numbers, in the order 6, 3, 4, 8, are in *inverse proportion,* since the *direct ratio* $\frac{6}{3}$ of 6 to 3 is equal to the *inverse ratio* $\frac{8}{4}$ of 4 to 8.

What is the *inverse fourth proportional* to 12, 6, and 8; that is, the number to which 8 has the *inverse ratio* of 12 to 6?

What is the inverse fourth proportional to 8, 2, and 3? To 3, 9, and 15? To 4, 20, and 30? To 24, 3, and 4?

The term *proportion*, used alone, always means *direct* proportion.

Variation or General Proportion.

§ 220. VARIATION expresses the *dependence* of one term or quantity on another, according to some constant ratio, whatever *new value* either of the terms may assume.

One term *varies directly* as another, when both *increase* or *decrease* together in the same ratio.

Thus the *value* of a particular commodity *varies directly* as the *quantity*, since the value will be *multiplied* by 2, or 3, &c., if the quantity be *multiplied by the same number*. More briefly, we say, the value *is directly as* the quantity; or, the value *is as* the quantity.

One term *varies inversely* as another, when one of them *increases* in the same ratio in which the other *decreases*.

Thus the *time* required for a laborer to earn a given sum, *varies inversely* as his *rate of wages*, since the time will be *multiplied* by 2, or 3, &c., if his rate of wages be *divided* by the same number. More briefly, we say, the time is *inversely* as his rate of wages.

Say whether the two *italicised terms* would vary *directly*, or *inversely*, with each other, in each of the following instances:

1. The *value* and the *quantity* of a piece of cloth?—The *time*, and the *number* of men required for a given amount of labor?

2. The *weight* and the *number* of gallons of water?—The *number* of men and the *amount* of provisions that will serve them for a given period of time?

3. The *weight* of an article and the *distance* it may be carried for a given sum of money?—The *length* and the *breadth* of a garden to contain a given area?

4. The *weight* of the five-cent loaf of bread and the *price* of flour?—A *sum* of money and the *number* of laborers that may be hired with it for a given time?

Variation is sometimes called *General Proportion:* being, indeed, an abridgement of a proportion containing four terms without respect to any *particular values* of those terms.

Thus when we say that the *weight* of water *is as* the *number of gallons*, it is understood that,

The *weight* of any *number* of gallons *is to* the weight of any other number of gallons, *as* the *first* of those numbers *is to* the second.

Sign of Proportion.

§ **221.** A Proportion is denoted by a *double colon* (: :), or the sign = *equal to*, between the two ratios of the proportion.

Thus $6 : 3 :: 8 : 4$
or $6 : 3 = 8 : 4$ denotes

that 6, 3, 8 and 4 are *in proportion;* and is read, 6 *is to* 3 *as* 8 *is to* 4.

The two ratios of a proportion may also be expressed *fractionally*, and the first be put equal to the second.

Thus $\frac{6}{3}=\frac{8}{4}$ denotes that the ratio 6 to 3 is equal to the ratio of 8 to 4, or that 6 *is to* 3 *as* 8 *is to* 4.

No sign has hitherto been adopted by Mathematicians for *inverse proportion.* We shall employ the *sign* $\neq$ between the two ratios of such proportion.

Thus $6 : 3 \neq 4 : 8$ denotes that 6, 3, 4, and 8 are in *inverse* proportion; and must be read, 6 *is to* 3 *inversely as* 4 *is to* 8.

Inverse Converted into Direct Proportion.

§ **222.** An *inverse* is converted into a *direct* proportion by *interchanging* either antecedent and its consequent, that is, by taking the antecedent and its consequent *the one for the other.*

Thus $6 : 3 \neq 4 : 8$ is an inverse proportion. By interchanging 6 and 3, we have $3 : 6 = 4 : 8$, which is a direct proportion.

An *inverse* may also be converted into a *direct* proportion, by substituting, for either antecedent and its consequent, the *reciprocals* of those terms.

Thus the inverse proportion $6 : 3 \neq 4 : 8$ is converted into the direct proportion $\frac{1}{6} : \frac{1}{3} = 4 : 8$, by substituting the reciprocals of 6 and 3. (§ 216).

Product of the Extremes = that of the Means.

§ **223.** In every direct proportion, the product of the *two extremes* is equal to the product of the *two means.*

In the proportion $3 : 6 = 4 : 8$, we have two *equal ratios* $\frac{3}{6}$ and $\frac{4}{8}$; and if these ratios be reduced to a *common denominator*, the resulting *numerators* must be equal. One of these numerators, 3×8, is the product of the two extremes, and the other, 6×4, of the two means.

In an *inverse* proportion, the product of the two *antecedents* is equal to that of the two consequents.

By interchanging 3 and 6 in the preceding proportion, we have the *inverse* proportion $6 : 3 \neq 4 : 8$; and $6 \times 4 = 3 \times 8$.

Fourth Proportional—how found.

RULE XLII.

§ 224. *To find a* FOURTH PROPORTIONAL *to three given terms.*

1. Multiply the second and third together, and divide the product by the first term ; the quotient will be the fourth term, in *direct* proportion.

2. An *inverse fourth proportional* may be found by interchanging the first and second terms, (§ 222), and then proceeding as above.

3. The *first* and *second* terms must be used in the *same denomination*.

4. When the *third* term is a *polynomial*, it will generally be most convenient to reduce it to a *monomial*, or single denomination.

5. The *fourth* term will be found in the *same kind* of quantity, and in the *same denomination*, with the *third* term.

EXAMPLE.

To find a fourth proportional to 3 *yd.*, 5 *yd.* 2 *qr.*, and 2£. 10 *s.*

Reducing the 1st and 2d terms to the *same denomination*, we find 3 *yd.* =12 *qr.* and 5 *yd.* 2 *qr.* =22 *qr.*

Reducing the third term to a single denomination, we find 2£. 10 *s.* =50 *s.*

Multiplying the 2d and 3d terms together, and dividing by the 1st term, we have

50 *s.* ×22÷12=1100 *s.* ÷12=91 *s.* 8 *d.* =4£. 11 *s.* 8 *d.*

The proportion is,

3 *yd.* : 5 *yd.* 2 *qr.* : : 2£. 10 *s.* : 4£. 11 *s.* 8*d.*

☞ The product of the second and third terms, is equal to the *product of the first and fourth ;* (§ 223) ; and the product of the *first* and *fourth* divided by the *first term*, gives the fourth term. (§ 66).

The first and second terms must be used in the *same denomination*, to be in the *proper ratio* to each other, in multiplying and dividing. (§ 213).

The third term, multiplied and divided, produces the fourth term in the me denomination. Thus, in the example, 50 *s.* ×22 produces 1100 *s.*; d this, divided by 12, gives $\frac{1}{12}$ of 1100 *s.* =91 *s.* 8 *d.* ☜

EXERCISES.

Find the *fourth term* in each of the following proportions.

1. 4 *yd.* : 7 *yd.* 2 *qr.* : : $26 : *4th term.* . . *Ans.* $48.75.
2. 3 *oz.* : 4 *lb.* 15 *dwt.* = $4 : *4th term.* . . *Ans.* $65.
3. 5 *men* : 12 *men* ≠ 18 *days* : *4th term.* . . *Ans.* 7½ days.
4. 10 *bu.* : 20 *bu.* 3 *pk.* : : $15 : *4t term.* . *Ans.* $31⅛.
5. 9 *days* : 4½ *days* ≠ 5 *bu.* 1 *pk.* : *4th term.* *Ans.* 10 *bu.* 2 *pk.*
6. $15 : $2.25 = 3 *A.* 10 *P.* : *4th term.* *Ans.* 1.8375 *R.*

APPLICATION OF PROPORTION.

§ **225.** The applications of Proportion are very numerous. It is involved in every multiplication and division of numbers.

For, a *unit* : the *multiplier* : : the *multiplicand* : the *product* ;
and, the *divisor* : a *unit* : : the *dividend* : the *quotient.*

In practical questions in Proportion, we shall always have given a term of *supposition* and a like term of *demand,* with a third term *dependent* on the term of *supposition,* and in ratio to the *answer* required, directly or inversely *as* the term of supposition *is to* that of demand.

These several particulars will be exemplified under

RULE XLIII.

§ **226.** *For solving questions by Proportion.*

1. Make the term of *supposition* the *first* term, the like term of *demand* the *second* term, and the *dependent* term the *third* term.

2. Consider whether the *answer* required would *vary directly* or *inversely* with the term of *demand,* and find it, accordingly, as a direct or inverse *fourth proportional.*

EXAMPLES.

1. If 3 yards of cloth cost $19, what will 15 yards cost?

The term of supposition is 3 yards, and the like term of *demand* is 15 yards; while $19 is the *dependent* term, since this term depends for its value on the 3 yards.

The *Proportion* is, 3 *yd.* : 15 *yd.* : : $19 : the *cost* of 15 *yd.*

The required cost of 15 *yd.* would *vary directly* with the 15 *yd.,* since these two terms would both *increase* or decrease together in the same ratio (§ 220).

The proportion is therefore *direct;* and the fourth *proportional* is

$19 × 15 ÷ 3 = $285 ÷ 3 = $95, (§ 224).

Ans. $95.

2. Allowing 6 men to perform a certain work in 30 days, in what time ought 13 men to perform the same work?

The term of supposition *is* 6 *men, and the like term of* demand *is* 13 *men.:* while the 30 days is *dependent on the* 6 *men.*

The *Proportion* is, 6 *men* : 13 *men* ≠ 30 *days* : the *time required.*

The *time* required for 13 men would vary *inversely* with the 13 men, since one of these two terms would *increase* in the same ratio in which the other would *decrease.*

The proportion is therefore *inverse:* and the inverse fourth proportional is

30 days × 6 ÷ 13 = 180 *da.* ÷ 13 = $13\frac{11}{13}$ days, (§ 224—2).
Ans. $13\frac{11}{13}$ days.

Inverse Proportion Discarded.

The preceding Rule recognizes *inverse proportion;* and this kind of proportion is employed in many of the higher applications of the subject. The following Rule will arrange the terms always in a *direct* proportion, and is the one now most commonly employed in Arithmetic.

RULE XLIV.

§ **227.** *For solving questions by Direct Proportion.*

1. Make the term which is of the same kind with the required fourth term, or *answer,* the *third term.*

2. If the nature of the question requires the answer to be greater than the 3d term, make the *greater* of the two remaining terms the *second term,*—otherwise, make the *less* of those terms the 2d term: the term still remaining will be the *first* term.

3. Find the direct *fourth proportional,* for the answer.

EXAMPLE.

If 6 men perform a certain work in 30 days, in what time ought 13 men to perform the same work?

30 days *is the term of the* same kind *with the answer, and the answer will be less than* 30 *da.*, since 13 men would require less time than 6 men. Hence the direct proportion will be

13 *men* : 6 *men* : : 30 *da.* : the *time required.*

The fourth proportional, or *Ans.* is 30 *da.* × 6 ÷ 13 = $13\frac{11}{13}$ days.

EXERCISES.

The following questions may be put into *proportions*, or may be solved *analytically* (§ 209). Cancellation may be employed in many of them, to abbreviate the operations of multiplying and dividing (§ 210 and 211).

If the last Rule be preferred, it is recommended that the student be required to express, in general terms, the *kind of proportion* naturally involved in the question; as under Ex. 1 and 2.

1. If 9 acres of land sell for $230.62½, what should 5 acres bring at the same rate?

The value of the land is directly *as the quantity*.

Ans. $128.125.

2. If 1.5 *T.* of iron be hauled 40 miles for a given sum, how far ought 3 *T.* to be hauled for the same sum?

The distance is inversely *as the weight* to be hauled.

Ans. 20 miles.

3. What will 14 pounds of tea amount to, when 6 pounds of the same kind cost $7.50? *Ans.* $17.5.

4. What quantity of cloth may be bought for $73.75, when 4.25 yards of the same kind cost $12.75? *Ans.* 24.583' *yd.*

5. If 7 masons can build a house in 28 days, in what time ought 17 masons to build the house? *Ans.* $11\frac{9}{17}$ days.

6. If 35 pounds of coffee cost $5, how many pounds of the same sort may be purchased for $100.25? *Ans.* 701.75 *lb.*

7. If a man travels at the rate of 100 miles in 3 days, how many miles ought he to travel in 13½ days? *Ans.* 450 miles.

8. If a quantity of bread will suffice 100 men for 29 days, how long ought it to suffice 84 men? *Ans.* $34\frac{11}{21}$ days.

9. If 5 yards of silk cost $6.25, what should be paid for 12 *yd.* 3 *qr.* of silk, at the same rate? *Ans.* $15.937'.

10. Allowing 4 horses to consume 13 *bu.* 3 *pk.* of oats in a week, how much would 9 horses require for a week?

Ans. 30.937' *bu.*

11. Allowing the transportation of 10 *cwt.*, 100 miles, to cost $25, what should be paid for the transportation of 33 *cwt.* 2 *qr.* the same distance? *Ans.* $83.75.

12. Allowing a person, by traveling 10 hours a day, to perform a journey in 31 days; in how many days ought he to perform the same journey, if he travel 13 hours a day?

Ans. $23\frac{11}{13}$ days.

13. What sum should be paid for ¾ of a yard of cloth, when 9 *yd.* of the same kind cost $54? *Ans.* $4½.

14. If 7 men can do a certain work in ⅜ of a day, in what time ought 9 men to do the same work? *Ans.* $\frac{7}{24}$ of a day

15. If 17 *bu.* of salt cost $8.50, what should be paid for 20 *bu.* 3 *pk.* of salt at the same rate? *Ans.* $10.375.

16. If 5 *cwt.* of goods be carried 100 miles for a given sum, how far ought 20 *cwt.* 1 *qr.* to be carried for the same sum? *Ans.* $24\frac{56}{81}$ miles.

17. If 10 head of cattle require 20 *A.* 2 *R.* of pasture ground, for a summer, how many acres ought 25 head to have, for the same length of time? *Ans.* 51 *A.* 1 *R.*

18. Allowing the transportation of 15 *T.*, a given distance, to cost $$25\frac{1}{2}$, what should be charged for the transportation of $3\frac{1}{4}$ *T.* the same distance? *Ans.* $5.525.

19. If a ship sail 194 *L.* in $5\frac{1}{2}$ days, in how many days would she sail 3000 miles, at the same rate? *Ans.* $28\frac{34}{97}$ days.

20. An army of 5000 men had provisions for 3 months. One-eighth of the men having been killed in battle, how long ought the same provisions to last the remainder? *Ans.* $3\frac{3}{7}$ months.

21. If $\frac{3}{4}$ of a *cwt.* of iron cost $16, what will $\frac{7}{8}$ of a *cwt.* cost at the same rate? *Ans.* $$18.66\frac{2}{3}$.

22. What should be paid for $\frac{5}{8}$ of a *yd.* of crape, when $\frac{1}{2}$ *yd.* of the same kind costs $1.75? *Ans.* $2.1875.

23. What should be paid for $15\frac{1}{2}$ *gal.* wine, when 3 quarts of the same sell for $$0.56\frac{1}{4}$? *Ans.* $11.625.

24. If $1\frac{1}{4}$ *A.* of land sell for $34.50, what will 20 *A.* 2 *R.* 10 *P.* amount to, at the same rate? *Ans.* $567.525.

25. A cistern is filled with water, by 2 pipes, in 3 *hr.* 25 *m.* In what time would it be filled by 5 pipes of like size? *Ans.* 1 *hr.* 22 *min.*

26. A sum of money having been equally divided among 19 men, each man received $$3\frac{1}{4}$. If the number of men had been 30, what would have been the share of each? *Ans.* $2.058'.

27. Allowing a person to perform a certain journey in 15 days, when the days are $10\frac{1}{2}$ hours long; in what time ought he to accomplish the same journey, when the days are 13 *hr.* long? *Ans.* $12\frac{3}{26}$ days.

28. If 950 *lb.* of beef be sufficient for the crew of a ship for 57 days; how much would suffice them for $83\frac{1}{2}$ days? *Ans.* $1391\frac{38}{57}$ *lb.*

29. Allowing 15 *A.* 30 *P.* to produce 403 *bu.* 2 *pk.* of wheat, what number of bushels would be raised from a field containing 40 *A.*, at the same rate? *Ans.* $1062\frac{58}{81}$ *bu.*

30. If 5 *T.* 11 *cwt.* of hay amount to $$55.18\frac{3}{4}$, what quantity of hay, at the same price per ton, may be bought for $100? *Ans.* 10.056' *T.*

31. If 25 sacks, each measuring 4 *bu.* will contain a given quantity of grain; how many sacks, each measuring $3\frac{1}{2}$ *bu.*, will contain the same quantity? *Ans.* $28\frac{4}{7}$ sacks.

32. A bought $9\frac{7}{8}$ *yd.* of linen, for $19.75; and B bought 7 *yd.* $1\frac{1}{2}$ *qr.* at the same price per yard? What did the latter pay for the quantity he purchased? *Ans.* $14.75.

33. A post, standing in a stream, has $\frac{1}{5}$ of its length in the earth, $\frac{2}{3}$ in the water, and 5 feet above the water. What is the length of the post?

Analysis. $\frac{1}{5}+\frac{2}{3}=\frac{3}{15}+\frac{10}{15}=\frac{13}{15}$; and $1-\frac{13}{15}=\frac{2}{15}$

The post has $\frac{13}{15}$ of its length below the surface of the water, and, consequently, $\frac{2}{15}$ of its length above the water.

Then $\frac{2}{15}$ of its length is 5 *feet;* $\frac{1}{15}$ of it is $\frac{1}{2}$ of 5 *ft.* $=\frac{5}{2}$; and the whole length is 15 times $\frac{1}{15}$ of it $=\frac{5\times15}{2}=\frac{75}{2}=37\frac{1}{2}$ *ft.*

Proportion. $\frac{2}{15}$: 1 or $\frac{15}{15}$ :: 5 *ft.* : *The entire length.*

The part of the post above the water, *is to* the *whole post,—* represented by a *unit,—as* the length of that part *is* to the whole length.

34. A farmer sold $\frac{1}{3}$ of his land to A, $\frac{1}{4}$ of it to B, and the remainder, which was 100 acres, to C. How much land did the farmer own? *Ans.* 240 acres.

35. A merchant who owned $\frac{3}{8}$ of a ship's cargo, sold $\frac{1}{3}$ of his share for $1500. What was the whole cargo worth? *Ans.* $12000.

36. In a certain school, $\frac{1}{4}$ of the pupils are studying Arithmetic; $\frac{3}{8}$ of them study Languages; and the remaining 36 are employed on various other subjects. Required the number in the school. *Ans.* 96 pupils.

37. A person failing in business owes $5000, and is able to pay only $2000. How much can he pay per dollar to his creditors, and how much should that creditor receive to whom he owes $1000? *Ans.* $.40; and $400.

38. A traveler having gone 375.5 miles on his journey, finds that $\frac{3}{8}$ of it remains to be traveled. What was the length of his journey? *Ans.* 600.8 miles.

39. A given quantity of oats is allowed to 15 horses, for 31 days. If 7 horses more be added to the number, for how many days ought the same allowance of food to be made? *Ans.* $21\frac{3}{22}$ days.

40. A cistern whose capacity is 3000 *gal.* is supplied with water by a pipe which pours into it 7 *gal.* per minute. By leakage the cistern will lose, during the time of filling, at the rate of $2\frac{1}{2}$ *gal.* per minute. In what time will the cistern be filled? *Ans.* 11 *hr.* $6\frac{2}{3}$ *min.*

41. A and B depart from the same place, and journey in the same direction. A starts 3 days before B, and goes 30 miles per day; B follows at the rate of $33\frac{1}{3}$ miles per day. In how many days will the latter overtake the former?

Ans. 27 days.

42. If when flour is at \$5 a barrel, the five cent loaf of bread weighs 9 *oz.*, what ought to be its weight when flour is at \$7 a barrel?

The weight of the loaf ought to be inversely as the price of the flour.

Analysis. If flour were at \$1 a barrel, the loaf ought to weigh 5 times as much as if flour were at \$5 a barrel; that is, 9 *oz.* ×5.

And when flour is \$7 a barrel the loaf ought to weigh only $\frac{1}{7}$ as much as when it is \$1 a barrel; that is,

$$\frac{9\,oz.\times 5}{7}=\frac{45\,oz.}{7}=6\tfrac{3}{7}\,oz.$$

43. If a given store of meat will supply a company of soldiers for 100 days, allowing each man 2 *lb.* per day; what should the daily allowance be, if the time were extended to 135 days? *Ans.* $1\frac{13}{27}$ pounds.

44. A borrowed of B \$500, which he kept $3\frac{1}{2}$ years. On a subsequent occasion, A lends to B \$375; how long ought B to keep this latter sum, in return for the accommodation he had afforded A? *Ans.* $4\frac{2}{3}$ years.

45. A bankrupt owes \$5349.75, and has property amounting to \$2300. In an equitable distribution of his property, how much will a creditor receive whose claim is \$400?

Ans. \$171.970'.

46. A garrison of 90 men has provisions for 42 days. How many of the men must be discharged, that the remainder, without any diminution of rations, may be supported for 60 days? *Ans.* 27 men.

47. A gentleman who owned $\frac{2}{3}$ of a manufactory, sold $\frac{1}{4}$ of his share for \$3000. What was the estimated value of the whole establishment? *Ans.* \$18000.

48. How many miles must a person walk in $5\frac{1}{2}$ days, to accomplish a journey of 500.5 miles, at the same rate, in 15 days? *Ans.* 183.516' miles.

49. If 4 *T.* 13 *cwt.* of iron be carried 50 miles, for \$30, how far should 9 *T.* 5 *cwt.* 3 *qr.* be carried for the same sum?

Ans. 25.033' miles.

50. If 31 *A.* 3 *R.* of ground produce 1000 *bu.* 3 *pk.* of wheat, how many bushels will 51 *A.* 2 *R.* 24 *P.* produce, at the same rate? *Ans.* 1627.991' *bu.*

51. Allowing a man to do a certain work in 3 days, and a boy to do it in 5 days, in what time ought both together to do the work? *Ans.* $1\frac{7}{8}$ days.

Analysis. The man could do $\frac{1}{3}$ of the work, and the boy $\frac{1}{5}$ of the work, in 1 day; and $\frac{1}{3}+\frac{1}{5}=\frac{8}{15}$.

Hence, both together could do $\frac{8}{15}$ of the work in 1 day.

Then $\frac{1}{15}$ of the work would be done in $\frac{1}{8}$ of a day; and, consequently, the entire work would be done in 15 times $\frac{1}{8}$ *da.* $=\frac{15}{8}$ *da.* $=1\frac{7}{8}$ *days.*

Proportion. $\frac{8}{15}$: 1 (the whole work) : : 1 *da.* : Time required.

The *part* that both could do in 1 *da.*, *is to* the whole work,—represented by a *unit,—as* 1 *day* is to the time required.

52. A can dig a ditch in 5 days, B in 6 days, and C in 8 days. In what time could the three together dig the ditch?

Ans. $2\frac{2}{59}$ days.

53. Two masons together built a wall in 10 days. One of them could have built the wall himself in 15 days; in how many days could the other have done it? *Ans.* 30 days.

54. If 37 *cwt.* 3 *qr.* of coal be hauled 20 miles for $5.75, what sum should be paid for hauling 3 *T.* of coal three times that distance? *Ans.* $27.417'.

55. A merchant bought three pieces of cloth, each containing 25 *yd.* 2 *qr.* for $500; and sold 50 *yd.* of it at cost. What did the 50 yards amount to? *Ans.* $326.797'.

56. A could mow a meadow in 7 days, B in 9 days, and C in 11 days. In what time could the three together mow the meadow? *Ans.* $2\frac{215}{239}$ days.

57. If $\frac{3}{4}$ of $\frac{4}{5}$ of an acre of land sell for 18.18\frac{3}{4}$, what would a lot containing 7 *A.* 2 *R.* 13 *P.* bring at that rate?

Ans. $229.806'.

58. A farmer sold $\frac{2}{5}$ of his whole amount of land, at $25 an acre, and received for it $10000. What amount of land did the farmer own? *Ans.* 1000 acres.

59. A testator bequeathed $\frac{1}{2}$ of his estate to his only son, $\frac{2}{7}$ of it to his only daughter, and the remainder, which was $5000, to his widow. What was the value of his estate?

Ans. 23333\frac{1}{3}$.

60. A, B, and C together can excavate a reservoir in 5 days. A and B together can do it in 9 days; in what time could C alone do the work? *Ans.* $11\frac{1}{4}$ days.

61. Allowing a person to perform a certain journey in $13\frac{1}{2}$ days, by traveling 10 hours a day, in what time ought he to perform the journey if he travel $11\frac{1}{4}$ hours per day?

Ans. 12 days.

62. How many yards of linen $\frac{1}{2}$ *yd.* wide, will be equivalent to 30 *yd.* of another kind, which is $\frac{3}{4}$ *yd.* wide?

The quantity in square measure being the same, the *length will be inversely as the breadth.*

Observe that $\frac{1}{2}$ *yd.* is the term of *demand:* also, that 30 *yd.* is that term which is of the same kind with the required 4th term, since both express *length.*

Analysis. The length of each kind × the *breadth,* will produce the *square measure;* which is, therefore,

$$30\times\tfrac{3}{4}=\frac{30\times 3}{4}\ \textit{sq. yards.}$$

This divided by the *breadth* of the first kind, will give the *length* of the first kind; which is, therefore,

$$\frac{30\times 3}{4}\div\tfrac{1}{2}=\frac{30\times 3\times 2}{4}.$$

Canceling 2, we have $\frac{30\times 3}{2}=\frac{90}{2}=45$ *yards.*

63. How many yards of cotton $\frac{7}{8}$ *yd.* wide, will be required to line $4\frac{1}{2}$ yards of cloth which is $1\frac{1}{2}$ *yd.* wide?

Ans. $7\frac{5}{7}$ yards.

64. How many yards of carpeting which is $\frac{3}{4}$ of a yard wide, will be required to cover a floor that measures 25 feet in length, and 20 feet in breadth? *Ans.* $74\frac{2}{27}$ yards.

65. How many yards of paper $\frac{5}{8}$ *yd.* wide will be sufficient to cover the walls of a room 70 *ft.* in compass, and 10 *ft.* in height, allowing $\frac{1}{30}$ for windows, &c. *Ans.* $120\frac{8}{27}$ yards.

66. A farmer has a field 100 poles in length, and 45.25 poles in width. He wishes to lay off another field to contain the same quantity of ground, and be 80 poles in length; what must be its breadth? *Ans.* 56.5625 poles.

PARTITIVE PROPORTION.

§ **228.** PARTITIVE PROPORTION is proportion applied to dividing a given quantity into *two or more parts*, which shall be in a given *ratio*, one to another. The terms of the given ratio, or ratios, may be called the *proportional terms*.

For example: to divide $300 between A, B, and C, in the proportion of 2, 3, and 5; that is, so that A's share shall be to B's as 2 to 3, and B's to C's, as 3 to 5.

In this example, 2, 3, and 5, are the *proportional terms*, the *consequent* of the first ratio 2 to 3 being the *antecedent* of the second ratio 3 to 5.

Note. This part of Arithmetic is commonly called PARTNERSHIP or FELLOWSHIP.

RULE XLV.

§ **229.** *To divide a given quantity into* TWO *or* MORE PARTS *which shall be in a given* RATIO, *one to another.*

1. Add together all the given proportional terms. Then,

2. The *sum* of those terms *will be* to each term, separately, *as* the quantity to be divided *is to* each *corresponding part* of that quantity.

EXAMPLE.

To divide $300 between A, B, and C, in the proportion of 2, 3, and 5.

The sum of the proportional terms is $2+3+5=10$.

Then, 10 : 2 : : $300 : $\$300\times2\div10=\$60$, A's share;
10 : 3 : : $300 : $\$300\times3\div10=\$90$, B's share;
and 10 : 5 : : $300 : $\$300\times5\div10=\$150$, C's share.

Analysis. Suppose the whole sum $300 to be divided into $2+3+5=10$ *equal parts*. Then it is evident that
A must have 2, B 3, and C 5, of those parts; that is,

A's share is $\frac{2}{10}$ of $\$300=\$300\times2\div10=\$60$;
B's share is $\frac{3}{10}$ of $\$300=\$300\times3\div10=\$90$;
C's share is $\frac{5}{10}$ of $\$300=\$300\times5\div10=\$150$.

The expressions $\$300\times2\div10$, &c., for the several shares, found by the Analysis, are the same as those found by the Rule. Hence the Analysis *demonstrates the Rule*.

EXERCISES.

1. Divide $240 between three persons in such a manner that their shares shall be as 5, 4, and 3, respectively.

Ans. $100 ; $80 ; and $60.

2. A gentleman bequeathed to his son and daughter $5000, the son's share of it to be to the daughter's as 3 to 2. What was the share of each ?

Ans. Son's $3000 ; daughter's $2000.

3. A merchant employed 3 clerks, at the annual salaries of $300, $400, and $500, respectively. At the end of the year, the merchant proving bankrupt, has but $650 to be divided proportionably among them. What will be the portion of each ?

The proportional terms are 300, 400, *and* 500 ; or without altering the ratios, 3, 4, and 5 ; since $\frac{300}{400}=\frac{3}{4}$, and $\frac{400}{500}=\frac{4}{5}$.
Ans. The 1st, $162.5 ; the 2d, $216.666’; the 3d, $270.833’.

4. An insolvent debtor owes to A $250, to B $100, and to C $300. He is able to pay $420 ; what would each creditor receive of the $420 ?

Ans. A $161.538’; B $64.615’; C $193.846’.

5. It is required to divide the number 180 into three parts which shall be to one another as $\frac{1}{2}$, $\frac{2}{3}$, and $\frac{3}{4}$.

Analysis. Reducing the proportional terms to a *common denominator*, we have them $\frac{6}{12}$, $\frac{8}{12}$, and $\frac{9}{12}$; and *these are to one another as the numerators* 6, 8, and 9 ; (§ 217).

Hence 6, 8, and 9 may be taken for the *proportional terms*.

Ans. $46\frac{22}{23}$; $62\frac{14}{23}$; and $70\frac{10}{23}$.

6. A father proposed to divide $100 between his two sons in the ratio of $\frac{1}{3}$ to $\frac{1}{2}$, provided either of them could ascertain the portion offered to him. What would each portion be ?

Ans. The 1st, $40 ; the 2d, $60.

7. The sum of $500 is to be divided among A, B, and C, in the proportion of $\frac{2}{3}$, $1\frac{1}{4}$, and $2\frac{1}{2}$, respectively. What will be the share of each ?

Ans. A's $75.471’; B's $141.509’; C's $283.

8. Two persons form a partnership in trade, with a capital of $3000, of which the first contributed $1800, and the second the remainder. They gain $900 : what is each one's share ?

Ans. The first, $540 ; the second, $360.

9. A bankrupt is indebted to A $425.50 ; to B $200 ; to C $100 ; and to D $85.75. He is able to pay $500. If this sum be divided among his creditors proportionably to their respective claims, what will be the share of each ? *Ans.* A's $262.249’; B's $123.266’; C's $61.633’; D's $52.85’.

When each given Ratio has a separate Antecedent and Consequent.

§ **230.** In Partitive Proportion, *when each given ratio has a separate antecedent and consequent,*—take, for the proportional terms, the given 1*st* and 2*d* terms, the *fourth proportional* to the 3*d*, 4*th*, and 2*d* terms, the fourth proportional to the 5*th* and 6*th* terms, and *last fourth proportional,*—and so on to the last term.

EXAMPLE.

10. Divide $1700 between A, B, C, and D, so that A's share may be to B's as 1 to 2, B's to C's as $\frac{1}{3}$ to 1, and C's to D's as 3 to 4.

The given first and second terms are 1 and 2;

finding a *fourth proportional* to the 3d, 4th, and 2d terms, Rule XLII, we have $\frac{1}{3} : 1 :: 2 : 2\times1\div\frac{1}{3}=6$; and finding a fourth proportional to the 5th and 6th terms, and last *fourth proportional* 6, we have $3 : 4 :: 6 : 6\times4\div3=8$.

Now since B's share is to C's as $\frac{1}{3}$ to 1, or as 2 to 6;
and since C's share is to D's as 3 to 4, or as 6 to 8;

the four shares will be to one another as the numbers 1, 2, 6, and 8, which we accordingly take for the *proportional terms.*

Then 17 : 1 : : $1700 : $100, A's share.

In like manner B's is $200, C's $600, and D's $800.

11. Divide $70 between A, B, and C, in such a manner that A's share shall be to B's as 2 to 3, and B's to C's as 4 to 5.

Ans. A's share $16, B's $24, and C's $30.

12. Three persons in a joint speculation gain $1000; which is to be divided so that the first share shall be to the second as 3 to 2, and the second to the third, as 5 to 6. Required the shares. *Ans.* $405.405', $270.270', and $324.324'.

13. A, B, and C, in partnership, lose $800. A's portion of the capital employed was $\frac{3}{4}$ of B's, and B's was $\frac{2}{3}$ of C's: what amount of the loss should be assigned to each?

Observe that A's capital was to B's as 3 *to* 4, *and B's to C's as* 2 *to* 3; and that their respective losses should be in like proportion.

Ans. To A $184.615', to B $246.153', and to C $369.230'.

14. A farmer divided 500 acres of land between his three sons, giving to the first $1\frac{1}{2}$ times as much as to the second, and to the second $1\frac{1}{4}$ times as much as to the third. How much did he give to each?

The first share was to the second as $1\frac{1}{2}$ *to* 1, *and the second to the third as* $1\frac{1}{4}$ *to* 1.

Ans. To the 1st, $227\frac{9}{33}$, to the 2d, $151\frac{17}{33}$, to the 3d, $121\frac{7}{33}$ *A.*

Partitive Ratios dependent on Time.

§ 231. When *different periods* of *time* are involved in Partitive Proportion, the proportional terms to be used will be found by multiplying each term reckoned with time, by *its time.*

The different periods of time, before multiplying, must all be in the same denomination.

EXAMPLE.

15. Two persons, A and B, trade together; A ventures $200 for 7 months, and B $300 for 9 months. They gain $100; how must it be divided between them?

$200 for 7 *mo.* is equivalent to (200×7) $1400 for 1 *mo.*
and $300 for 9 *mo.* is equivalent to (300×9) $2700 for 1 *mo.*

Having the time the same, that is, 1 month, in both cases, we take 1400 and 2700, or 14 and 27, for the proportional terms. without regard to time.

Ans. A must have $34.146', B $65,853'.

16. Three persons rent a pasture for $20. A put in 20 sheep for 4 months, B 36 sheep for 3 months, and C 45 sheep for 2 months: how much of the rent should accordingly be paid by each?

Ans. A must pay $5.755', B $7.769', C $6,474'.

17. E, F, and G, in partnership, have made $400. What will be the share of each, supposing E's stock in the business to have been $500 for 10 months, F's $900 for 1 *yr.* 3 *m.*, and G's $600 for 2 years?

Ans. E's $60.790', F's $164.133', G's $175.075.

18. A and B invested capital in a joint speculation as follows: A put in at first $1000, and 6 months after $500 more; B advanced at first $2000, and 4 months after withdrew $600. At the end of 12 months the profits amounted to $800: what was each one's share of the same?

A employed $1000 for 6 *m.*; $1000×6=$6000 for 1 *m.*;
and $1500 for 6 *m.*; $1500×6=$9000 for 1 *m.*

Then A's capital was equivalent to $15000 for 1 *month.*

In like manner find the equivalent for B's capital.

Ans. A's $350.877', B's $449.122'.

19. A, B, C, and D engaged in partnership for 2 years. At the outset A advanced $2000, B $3000, C and D each $4000. Six months afterwards A added $500 to his stock in the business, B $300, and C and D each withdrew $1000. At the end of the 2 years, the profits were found to be $800; to what amount of profit was each one entitled?

Ans. A $157.024', B $213.223', C and D each $214.876'.

MEDIAL PROPORTION.

§ 232. **Medial Proportion** is Proportion applied to finding in what *ratio* to one another two or more quantities, at *different rates* of value, must be taken, to form a compound of a given *medial or mean rate of value.*

For example, to find in what ratio to each other, rye at 37 *cents* per bushel, and oats at 25 *cents* per bushel, must be mixed together, that the mixture may be worth 30 *cents* per bushel.

Note. This part of Arithmetic is commonly called Alligation.

RULE XLVI.

§ 233. *To find the ratio of* two *or* more quantities *at different rates of value, for a* compound *of a given mean rate of value.*

1. *For two different rates*—take the quantities *inversely* as the *differences* between their respective rates and the mean rate.

2. *For three or more different rates*—find the ratio for one rate which is *less*, and another which is *greater*, than the mean rate as above; then for one of these two rates and another, or for two others, in like manner; and so on, until all the different rates are included, and add together all the *proportional terms found for the same rate.*

EXAMPLE.

To find in what ratio to each other, rye at 37 *cents*, and oats at 25 *cents* a bushel, must be mixed together, that the mixture may be worth 30 *cents* a bushel.

The differences between the rates of the *two ingredients* and the *mean rate* 30 cents, are

for the *rye* $37-30=7$, and for the *oats* $30-25=5$.

Then the quantity of rye will be to that of oats *inversely as* 7 *to* 5; and by converting the *inverse* into a *direct* proportion (§ 222), we find the quantity of rye to that of oats as 5 to 7; that is, the mixture must be in the ratio of 5 bushels of rye to 7 bushels of oats.

In other words, since $5+7=12$, $\frac{5}{12}$ of the mixture must be rye, and $\frac{7}{12}$ must be oats, whatever be the quantity of the mixture.

Analysis. We wish to find in what ratio to each other, rye at 37 *cents*, and oats at 25 *cents* a bushel, must be mixed together, that the mixture may be worth 30 *cents* a bushel.

On 1 bushel of *rye* there is an *excess* of 7 cents *above*, and on 1 *bu.* of *oats* a deficiency of 5 *cts. below*, the *mean rate* 30 *cts.*

Then $\frac{1}{7}$ *bu.* of rye is in *excess* 1*ct.*, and $\frac{1}{5}$ *bu.* of oats is *deficient* 1 *ct.*, in relation to the mean rate.

This equal excess and deficiency *counterbalance each other.* Hence, $\frac{1}{7}$ *bu.* of rye and $\frac{1}{5}$ *bu.* of oats, mixed together, will be at *the mean rate.*

Again; $\frac{1}{7}=\frac{5}{35}$, $\frac{1}{5}=\frac{7}{35}$; and $\frac{5}{35} : \frac{7}{35} :: 5 : 7$ (§ 217).

Hence, the mixture must be in the ratio of 5 bushels of *rye* to 7 of *oats.*

This result being the same as that found by the Rule, the Analysis demonstrates the *first part of the Rule.*

EXERCISES.

1. In what ratio to each other must corn at 40 *cts.* a bushel, and oats at 25 *cts.* a bushel, be taken, to form a mixture worth 33 *cts.* a bushel? *Ans.* 8 *bu.* of corn to 7 *bu.* of oats.

2. In what ratio must one kind of coffee at 9 *cts.* a *lb.* and another at 13 *cts.* a *lb.*, be taken, to form a mixture of the two which shall be worth 12½ *cts.* a *lb.*?
Ans. ½ *lb.* at 9 *cts.* to 3½ *lb.* at 13 *cts.*

3. In what ratio must one kind of wine at 90 *cts.* a gallon, and another at 75 *cts.* a *gal.*, be mixed, that the compound of the two may be worth 87½ *cts.* a gallon?
Ans. 12½ *gal.* at 90 *cts.* to 2½ *gal.* at 75 *cts.*

4. In what ratio must two kinds of tea, at 75 *cts.* and 90 *cts.* a pound, be mixed together, that the mixture may be worth 83 cents a pound? *Ans.* 7 *lb.* at 75 *cts.* to 8 *lb.* at 90 *cts.*

5. In what ratio should two different kinds of sugar, at 9½ *cts.* and 14 *cts.* a pound, be taken, to form a mixture which shall be worth 12½ *cts.* a pound?
Ans. 1½ *lb.* at 9½ *cts.* to 3 *lb.* at 14 *cts.*

6. In what ratio should two different kinds of raisins, worth 12½ *cts.* and 18¼ *cts.* a pound, be taken, to form a mixture which shall be worth 16⅔ *cts.* a pound?
Ans. 1$\frac{7}{12}$ *lb.* at 12½ *cts.* to 4⅙ *lb.* at 18¼ *cts.*

7. A farmer wishes to purchase two different qualities of land, rating at $20 and $35 per acre, in such quantities that the average rate shall be $27½ per acre. In what proportion must the two kinds be purchased?
Ans. 7½ acres, or equal quantities, of each.

8. A goldsmith wishes to form an alloy of gold which shall be 20 carats fine, from two alloys of the same metal, one of which is 23, and the other 18 carats fine. In what proportion must the two ingredients be taken?

Ans. 2 parts of 23, and 3 parts of 18 carats fine.

EXAMPLE,

Of three ingredients at different rates.

9. A farmer wishes to mix rye at 37 *cts.*, oats at 23 *cts.*, and corn at 32 *cts.* per bushel, in such proportions that the mixture shall rate at 31 *cts.* per bushel; what must be the proportions?

Applying the second part of the preceding Rule, we first suppose the *rye* and the *oats* to be formed into a mixture at the *mean rate* 31 *cts.*

This would require 8 bushels of *rye* to 6 bushels of *oats.*

We next suppose the *oats* and the *corn* to be formed into a mixture at the mean rate 31 *cts.*

This would require 1 bushel of *oats* to 8 bushels of *corn.*

The two mixtures thus formed, if *mixed together,* will evidently be at the mean rate; and this would give a mixture of the *three ingredients,* in the proportion of 8 bushels of *rye,* to 8 bushels of *corn,* and $6+1=7$ bushels of *oats.*

Observe that the proportion of *oats* in the mixture of the three ingredients, is found by adding together the proportional terms 6 and 1, found for the *oats* in the mixtures of the same ingredients taken *two and two.*

Since $8+8+7=23$, $\frac{8}{23}$ of the mixture will be rye, $\frac{8}{23}$ of it *corn,* and $\frac{7}{23}$ of it *oats,* whatever be the quantity of the mixture.

10. A merchant wishes to mix three kinds of tea, which rate at 90 *cts.*, $1, and $1.50 per *lb.*, in such portions that the compound shall rate at $1.25 per *lb.* In what ratios must the different kinds be taken?

Ans. 25 *lb.* at 90 *cts.*, to 25 *lb.* at $1, and 60 *lb.* at $1.50

11. A grocer mixed brandy at 30 *cts.* per *gal.*, and wine at $1 per *gal.*, with water, and found the compound to be worth 50 *cts.* per gallon. What ratios of the ingredients did he take,—the water being rated at 0?

Ans. 50 *gal.* of brandy to 70 of wine and 50 of water.

12. A farmer has one tract of land worth $15 an acre, another worth $22 an acre, and another worth $25 an acre. In what proportion must he sell from the several tracts, that the average price received shall be $20 an acre?

Ans. 7 acres at $15 to 5 at $22 and 5 at $25.

Different Ratios of the same Ingredients may sometimes be found.

§ 234. In Medial Proportion, when there are two or more rates *greater*, and two or more *less*, than the mean rate, *different ratios for the same ingredients* may be found, according to the different ways in which the ingredients may be taken, two and two, in adjusting them to the mean rate.

EXAMPLE.

13. Four different kinds of sugar, rating at 5 cents, 8 cents, 13 cents, and 14 cents, per *lb.* are to be formed into a mixture which shall rate at 10 cents per pound. What ratios must be taken?

Adjusting the two at 5 cents and 13 cents to the mean rate 10 cents, we find 3 *lb.* at 5 cents to 5 *lb.* at 13 cents.

Adjusting the two at 8 cents and 14 cents to the mean rate 10 cents, we find 4 *lb.* at 8 cents to 2 *lb.* at 14 cents.

Then 3 *lb.* at 5 cents, 4 *lb.* at 8 cents, 5 *lb.* at 13 cents, and 2 *lb.* at 14 cents, will form a mixture at the mean rate 10 cents.

Find other ratios for the four ingredients, according to each of the following different ways of adjusting the four different rates, taken two and two, to the mean rate 10 cents.

1*st.* 5 cents and 13 cents; 5 cents and 14 cents; 8 cents and 13 cents. *Ans.* 7 *lb.* at 5 *cts.*, 7 *lb.* at 13 *cts.*, 5 *lb.* at 14 *cts.*, 3 *lb.* at 8 *cts.*

2*d.* 5 cents and 13 cents; 8 cents and 13 cents; 8 cents and 14 cents. *Ans.* 3 *lb.* at 5 *cts.*, 7 *lb.* at 13 *cts.*, 7 *lb.* at 8 *cts.*, 2 *lb.* at 14 *cts.*

3*d.* 5 cents and 14 cents; 8 cents and 13 cents; 8 cents and 14 cents. *Ans.* 4 *lb.* at 5 *cts.*, 7 *lb.* at 14 *cts.*, 7 *lb.* at 8 *cts.*, 2 *lb.* at 13 *cts.*

4*th.* 5 cents and 14 cents; 5 cents and 13 cents; 8 cents and 14 cents. *Ans.* 7 *lb.* at 5 *cts.*, 7 *lb.* at 14 *cts.*, 5 *lb.* at 13 *cts.*, 4 *lb.* at 8 *cts.*

When the Quantity at one of the different Rates, is given.

§ 235. In Medial Proportion, when the *quantity at one of the different rates,* is given, and the other quantity or quantities for a compound of a given mean rate, are required,—find the ratios for *all the different rates* as before; then,

The term found for the rate whose *quantity is given, will be to* that given quantity, *as* the term found for any other rate, *is to* the quantity required at that rate.

EXAMPLE.

14. How many pounds of tea at 85 *cts.* a *lb.*, and at 90 *cts.* a *lb.*, must be mixed with 5 *lb.* at $1 a *lb.*, that the mixture may be worth 94 *cts.* a *lb.*?

Finding the ratios at the three different rates, for a mixture at the mean rate 94 *cts.*, we have, 6 *lb.* at 85 *cts.*, 6 *lb.* at 90 *cts.*, and 13 *lb.* at $1.

Then 13 *lb.* : 5 *lb.* : : 6 *lb.* : the quantity required at 85 *cts.*; and in like manner is found the quantity required at 90 cents.

Ans. 2$\frac{4}{13}$ pounds of each.

15. How many ounces of gold 23 carats fine, and how many 20 carats fine, must be compounded with 8 ounces 18 carats fine, that the alloy of the three different qualities may be 22 carats fine?

Ans. 48 *oz.* of the first; and 8 *oz.* of the second.

When the Quantities at two or more of the different Rates, are given.

§ **236.** In Medial Proportion, when the quantities at *two or more* of the different rates are given,—find at what rate the *sum* of the given quantities should be estimated, by dividing said sum into the sum of the *values* of those quantities. Then,

By substituting the *sum* of the given quantities, and *its rate* thus found, for those separate quantities, and their respective rates, the question may be solved like those in the preceding section (§235.)

EXAMPLE.

16. How many gallons of vinegar at 20 *cts.* a *gal.*, and at 50 *cts.* a *gal.*, should be mixed with 4 *gal.* at 25 *cts.* a *gal.*, and 2 *gal.* at 16 *cts.* a *gal.*, that the whole may be worth 28 cents a gallon?

The 4 *gal.* at 25 *cts.* a gallon amount to 100 *cts.*, and the 2 *gal.* at 16 *cts.* amount to 32 *cts.* We have then $4+2=6$ *gal.* amounting to $100+32=132$ *cts.* Hence these 6 *gal.* rate at $132\div6=22$ *cts.* per *gal.*

Substituting now 6 *gal.* at 22 *cts.* per *gal.*, for the 4 *gal.*, and the 2 *gal.*, at their respective rates, the question becomes of the same nature as the 14th, preceding.

Ans. 6 *gal.* at 20 *cts.*, and 3$\frac{9}{11}$ *gal.* at 50 *cts.*

17. A farmer wishes to mix 10 bushels of corn at 35 *cts.* per bushel, and 8 bushels of rye at 40 *cts.* per bushel, with such a quantity of oats at 25 *cts.* per bushel, that the whole may be worth $.33$\frac{1}{3}$ per bushel. What quantity of oats must be taken? *Ans.* 8$\frac{2}{5}$ bushels.

When the Sum of the Quantities at the several different Rates, and the mean Rate or value of the whole, are given,—to find the Quantity at each particular rate.

§ **237.** Find the ratios of the several different kinds, for a compound at the given mean rate. (§ 233). Then,

The *sum* of the terms or quantities thus found, *will be to* the quantity found for either rate; *as* the *given sum* of all the quantities, *is to* the quantity *required for that rate.*

EXAMPLE.

18. A vintner wishes to mix two kinds of wine, which rate at \$.75 and \$1.25 per gallon, in such proportion and quantities as to produce 100 gallons which shall be worth \$.87½ per gallon. What quantities of the two kinds must be taken ?

The ratio of the two kinds for a compound at the mean rate \$.87½, will be found to be,

37½ *gal.* at \$.75, and 12½ *gal.* at \$1.25.

Then 37½+12½ : 37½ : : 100 : quantity required at \$.75.
Ans. 75 *gal.* at \$.75, and 25 *gal.* at \$1.25.

19. How many pounds of each of three different kinds of coffee, rating at 12 cents, 13 cents, and 15½ cents, a pound, respectively, must be taken for a mixture of 100 *lb.* which shall rate at 14 cents a pound ?

Ans. 25 *lb.* at 12 *cts.*, 25 *lb.* at 13 *cts.*, 50 *lb.* at 15½ cents.

20. How many bushels of each of three different kinds of grain, which rate at \$.20, \$.37½, and \$.75, per bushel, respectively, must be taken to produce a mixture containing 500 bushels, which shall rate at \$.50 per bushel ? *Ans.* $135\frac{5}{37}$ *bu.* at \$.20, $135\frac{5}{37}$ *bu.* at \$.37½, and $229\frac{27}{37}$ *bu.* at \$.75.

CONJOINED PROPORTION.

§ 238. A CONJOINED PROPORTION consists of two or more pairs of *equivalent terms*—each consequent being of the same kind as the next antecedent, and the first and last terms also of the same kind.

Its application will be seen under

RULE XLVII.

§ 239. *For the solution of questions in Conjoined Proportion.*

1. Set equivalent terms on the left and right of the sign =, one under another, and so that each succeeding left hand term shall be of the same kind with the preceding right hand one.

2. If the answer is to be of the same kind with the first term, set the *odd term* on the left;—otherwise, set it on the right.

3. All the terms on the same side with the odd term, must be multiplied together, for a dividend; and all the others, for a divisor. The quotient will be the answer, in the denomination of the given term of the same kind.

4. Each consequent and the next antecedent must be used in the same denomination.

EXAMPLE.

If 3 *qr.* of cloth be worth 4 *gal.* of wine, and 2 *gal.* of wine be worth 5 *lb.* of tea, how many quarters of cloth will be equal in value to 12 pounds of tea?

The equivalent terms are 3 *qr.* and 4 *gal.*; 2 *gal.* and 5 *lb.*; the *odd term* is 12 *lb.*; and the answer required is of the same kind with the 3 *qr.* Hence the arrangement will be,

3 *qr.* = 4 *gal.*;
2 *gal.* = 5 *lb.*;
12 *lb.* = how many *qr.* of cloth?

The operation is $3\times2\times12\div4\times5=72\div20=3\frac{3}{5}$ *qr.*

☞ The terms being *equivalent in value* on opposite sides, if we had the equivalent of the 12 *lb.*, the product of the terms on one side would be *equivalent to the product of the terms on the other.*

Hence the product on the side on which the number of terms is *complete*, divided by the *incomplete product* on the other side, gives the term *wanting on this latter side.* ☜

Analysis. 3 *qr.* of cloth being equal *in value* to 4 *gal.* of wine, and 2 *gal.* of wine to 5 *lb.* of tea, we wish to find how many *qr.* of cloth are equal in value to 12 *lb.* of tea.

$$\text{Since } 5\,lb. = 2\,gal.,\ 1\,lb. = \tfrac{1}{5} \text{ of } 2\,gal.;$$
$$\text{and } 2\,gal., \text{ being } \tfrac{2}{4} \text{ of } 4\,gal., = \tfrac{2}{4} \text{ of } 3\,qr.;$$
$$\text{hence } \quad 1\,lb. = \tfrac{1}{5} \text{ of } \tfrac{2}{4} \text{ of } 3\,qr. = \frac{2\times3}{5\times4}\,qr.;$$
$$\text{and } 12\,lb. = 12 \text{ times } \frac{2\times3}{5\times4}\,qr. = 2\times3\times12\div5\times4.$$

By Proportion. $4\,gal. : 2\,gal. :: 3\,qr. : 3\times2\div4 = 1\tfrac{1}{2}\,qr.$
$1\tfrac{1}{2}$ *qr.* of cloth equals in value 2 *gal.* of wine, or 5 *lb.* of tea.

$$\text{Then } 5\,lb. : 12\,lb. :: 1\tfrac{1}{2}\,qr. : 1\tfrac{1}{2}\times12\div5 = 3\tfrac{3}{5}\,qr.$$

EXERCISES.

1. If 7 *bu.* of wheat be worth as much as 3 cords of wood; and 9 cords of wood as much as 2 tons of hay; how many bushels of wheat should be exchanged for 5 tons of hay? *Ans.* $52\frac{1}{2}$ bushels.

2. If A can do as much work in 5 days as B can do in 8 days; and B as much in 4 days as C can do in 11 days; in how many days could A do the same that C could do in 20 days? *Ans.* $4\frac{6}{11}$ days.

3. If 3 barrels of corn be given for 7 *bu.* of wheat; and 4 *bu.* of wheat for 13 of rye; and 15 of rye for 20 of oats; how many bushels of oats would be an equivalent for 10 barrels of corn? *Ans.* $101\frac{1}{9}$ bushels.

4. Allowing that in a certain factory 6 girls do as much work in a day as 4 boys; and 8 boys as much as 6 men; how many men would be required to do as much work as 20 girls? *Ans.* 10 men.

5. If $10\frac{1}{2}$ yards of silk cost $15.75; and $6 will purchase 1 yard of broadcloth; and $4\frac{1}{2}$ *yd.* of broadcloth be bartered for 25 *yd.* of Irish linen; how many yards of silk would be an equivalent for 40 yards of the linen? *Ans.* $27\frac{1}{5}$ yards.

6. Supposing A to earn as much money in 4 months as B earns in 6 months; and B as much in 5 months as C in 7 months; and C as much in 10 months as D in 3 months; in what time could D earn the same that A could earn in 12 months? *Ans.* $7\frac{14}{25}$ months.

7. If 12 *lb.* in the United States be equal to 10 *lb.* at Amsterdam; and 100 *lb.* at Amsterdam be equal to 120 *lb.* at Paris; how many pounds in the United States are equal to 100 *lb.* at Paris? *Ans.* 100 pounds

COMPOUND RATIO.

§ **240.** A *Simple Ratio* is the ratio of a single antecedent to its consequent; as the ratio of 3 to 5, equal to $\frac{3}{5}$.

§ **241.** A COMPOUND RATIO is the ratio of the *product* of two or more antecedents to that of their consequents; and is equal to the product of all the *simple ratios*.

Thus the *compound ratio* of 3 and 4 to 5 and 7, is the ratio of

$$3\times4 \text{ to } 5\times7,=\frac{3\times4}{5\times7}=\frac{3}{5}\times\frac{4}{7} \text{ or } \frac{3}{7}\times\frac{4}{5}.$$

The compound ratio $\frac{3\times4}{5\times7}$, we see, is equal to the product of the simple ratios of 3 to 5, and 4 to 7; or of 3 to 7, and 4 to 5

COMPOUND PROPORTION.

§ **242.** A COMPOUND PROPORTION is one in which the *compound ratio* of two or more antecedents to their consequents, is equal to the ratio of *a remaining antecedent* to its consequent.

$$\text{Thus } \left.\begin{matrix} 2 : 3 \\ 6 : 8 \end{matrix}\right\} :: 5 : 10, \text{ is a Compound Proportion;}$$

in which the compound ratio $\frac{2\times6}{3\times8}$ of 2 and 6 to 3 and $8=\frac{5}{10}$, the ratio of 5 to 10.

Compound Proportion is applied to the solution of questions which involve two or more simple proportions.

RULE XLVIII.

§ **243.** *To solve a question in* COMPOUND PROPORTION.

1. Take any two terms of the same kind, and the one of the same kind with the answer to be found, and dispose them in a *direct proportion*. (§ 227.)

2. Then take two other terms of the same kind, for another proportion whose *third term* is that of the *first proportion;* and so on, until all the terms are included.

3. Multiply the first terms together for a divisor, and the second and third together for a dividend: the quotient will be the answer required.

4. Each antecedent and its consequent must be used in the same denomination; as in simple proportion.

EXAMPLE.

If a footman can travel 150 miles in 5 days, when the days are 12 hours long, in how many days may he travel 275 miles, when the days are 10 hours long?

Taking first 150 *miles*, 275 *miles*, and 5 *days*, the question is,

If 150 *m.* be traveled in 5 days, in how many days may 275 *m.* be traveled? This gives the proportion,

150 *m.* : 275 *m.* : : 5 days : *Time required.*

Taking next 12 *hours*, 10 *hours*, and 5 *days*, the question is,

If when the days are 12 *hr.* long, 5 days be required, how many days will be required when they are 10 *hr.* long? This gives the proportion,

10 *hr.* : 12 *hr.* : : 5 days : Time required.

The *compound proportion* will then be,

$$\left.\begin{array}{r} 150\,m. : 275\,m. \\ 10\,hr. : \ 12\,hr. \end{array}\right\} : : 5 \text{ days} : \textit{Time required.}$$

The operation is,

$$275\times12\times5\div(150\times10)=16500\div1500=11 \text{ days.}$$

The reason of the operation will become more evident if the compound proportion be stated thus;

$$150\times10 : 275\times12 : : 5 \text{ days} : \textit{Time required.}$$

From this it appears that the time required, is a fourth proportional to 150×10, 275×12, and 5 days.

Analysis. Recollecting that we are to find a number of *days*, and supposing at first that the days in both cases are 12 *hr.* long,

1 mile would be traveled in $\frac{1}{150}$ of 5 days; that is, $\frac{5\,d.}{150}$;

and 275 *m.* would require 275 times as long as 1 *m.*; $\frac{5\,d.\times275}{150}$.

With regard now to the different length of the days. If the days were but 1 *hour* long, the number of days would be 12 times as great as when they are 12 *hr.* long;

that is, $\frac{5\,d.\times275\times12}{150}$.

And when the days are 10 *hr.* long, the number will be only $\frac{1}{10}$ as many as when they are but 1 *hr.* long,

that is, $\frac{5\,d.\times275\times12}{150\times10}$.

The expression thus found may be canceled, successively, by 5, 6, 5, 2, and 5. This will reduce it to 11 *days.* (§ 212).

EXERCISES.

1. If 5 oxen require an acre of grass for 9 days, how many acres will 20 oxen require for 30$\frac{1}{2}$ days? *Ans.* 13$\frac{5}{9}$ acres.

2. If 4 men eat 64 pounds of bread in 2 weeks, how many pounds will 16 men eat in 7 weeks? *Ans.* 896 pounds.

3. If a man travel 100 miles in 3 days of 13 hours length, how far might he travel in 33 days of 14$\frac{1}{4}$ hours length? *Ans.* 1205$\frac{10}{13}$ miles.

4. If 2 yards of cloth 1$\frac{1}{2}$ *yd.* wide, cost $10.25, what should be paid for 13 yards of like quality, which is 1$\frac{3}{4}$ *yd.* wide? *Ans.* 77.72\frac{11}{12}$.

5. If a family of 10 persons, in 2 weeks, spend $200, how long ought a family of 13 persons to be in expending $500? *Ans.* 3$\frac{11}{13}$ weeks.

6. If 6000 *lb.* of bread will supply a garrison of 100 men, for 2 months, how long will 12000 *lb.* supply three such garrisons? *Ans.* 1$\frac{1}{3}$ months.

7. If the conveyance of 20 *cwt.*, 40 miles, cost 15.87\frac{1}{2}$, what should be charged for the conveyance of 50 *cwt.* 3 *qr.*, 100 miles? *Ans.* $100.707'.

8. Allowing 4 men to mow 19 *A.* 3 *R.* 27 *P.* of meadow, in 5 days, how long ought 7 men to be employed in mowing 45 acres? *Ans.* 6.454' days.

9. If 11 *oz.* 8 *dr.* of bread be bought for 6$\frac{1}{4}$ cents, when flour sells at $5 a barrel, what quantity of bread should be bought for $.75, when flour sells at $6 a barrel. *Ans.* 7*lb.* 3*oz.*

10. Allowing the transportation of 15 *cwt.*, 100 miles, to amount to $45.50, how far ought 37 *cwt.* 1 *qr.* 20 *lb.* to be carried for $100? *Ans.* 88.079' miles.

11. If 25 men can dig a ditch 80 *ft.* long, 4 *ft.* wide, and 3 *ft.* deep, in 2 days, in what time ought 30 men to dig one 300 *ft.* long, 5 *ft.* wide, and 4 *ft.* deep? *Ans.* 10$\frac{5}{12}$ days.

12. Allowing 17 head of cattle to consume 5 *A.* 2 *R.* 10 *P.* of pasture, in 30 days, how many acres would be consumed by 40 head of cattle, in 50 days? *Ans.* 21 *A.* 3 *R.* 10$\frac{10}{51}$ *P.*

13. A contractor engaged to pave 15 miles of road in 12 months, and for that purpose employed 100 men. Seven months have now elapsed, and but 6 miles of the road have been completed; how many more men must be employed to finish the work in the time prescribed? *Ans.* 110 men.

EXAMINATION ON CHAPTER IX.

1. Find the ratio of $2\frac{1}{3}$ to 7, and of $\frac{2}{3}$ to $\frac{2}{5}$. *Ans.* $\frac{1}{3}$ and $1\frac{2}{3}$

2. Find the inverse ratio of $\frac{2}{3}$ of $\frac{3}{4}$ to $5\frac{1}{2}$. *Ans.* 11

3. Find the ratio of 3 *qr.* to 1 *cwt.* 2 *qr.* 20 *lb.* *Ans.* $\frac{21}{47}$.

4. Find the inverse ratio of 2 *cwt.* to 3 *qr.* 5 *lb.* *Ans.* $\frac{89}{224}$.

Find the 4th term in each of the following proportions.

5. $3\frac{1}{2}$ days : 10 days : : $$37\frac{1}{2}$: 4th term. *Ans.* $$107\frac{1}{7}$.

6. 7 men : 13 men ≠ $21\frac{1}{2}$ days : 4th term. *Ans.* $11\frac{15}{26}$ days.

7. 3 *cwt.* 1 *qr.* : 7 *cwt.* : : $$25.12\frac{1}{2}$: 4th term. *Ans.* $54.115'.

8. $30\frac{3}{4}$ miles : 100 miles ≠ 14 *T.* 1 *cwt.* : 4th term. *Ans.* 4 *T.* 6.407' *cwt.*

9. If $13\frac{3}{4}$ yards of broadcloth cost $65.25, what should be paid for 17 *yd.* $2\frac{1}{2}$ *qr.* of cloth at the same rate? *Ans.* $86.794'.

10. Allowing $9\frac{1}{2}$ barrels of flour to suffice a family for 12 months, how many barrels would the same family require for 2 *y.* 4 *m.*? *Ans.* $22\frac{1}{6}$ barrels.

11. If $100 will supply a number of horses with oats, for 3 months, when oats is at 25 *cts.* per *bu.*, how long will the same sum supply them with the same article, when it is at $$0.37\frac{1}{2}$ per bushel? *Ans.* 2 months.

12. Supposing a company of workmen to erect a building in 30 days, by working $8\frac{1}{2}$ hours per day; in how many days ought the work to be accomplished, if they employ $10\frac{1}{4}$ hours per day? *Ans.* $24\frac{36}{41}$ days.

13. A farmer bought 100 *A.* of land for $5500, and afterwards sold 37 *A.* 3 *R.* 29 *P.* at the same price per acre. What did the portion sold amount to? *Ans.* $2086.218'.

14. A father dying left his son a fortune, of which he spent $\frac{1}{4}$ in 2 years, $\frac{2}{3}$ of the remainder lasted him 3 years longer, when he had only $3000 left. What fortune did his father bequeath him? *Ans.* $12000.

15. Three pipes will separately fill a cistern with water in 3 hours, 4 hours, and 5 hours. If the three pipes discharge into the cistern together, in what time will it be filled? *Ans.* $1\frac{13}{47}$ hours.

16. If A could do a piece of work in 10 days, B in 12 days, and C in 15 days, in what time could A and B together do it? In what time the three together do it? *Ans.* A and B in $5\frac{5}{11}$ days; A, B, and C in 4 days.

17. A merchant sold 4 *yd.* 3 *qr.* of cloth, at $5.25 per yard; 13 *yd.* 2 *qr.* of silk, at 1.12\frac{1}{2}$ per yard; and 7 *yd.* 2$\frac{1}{2}$ *qr.* of linen, at 0.62\frac{1}{2}$ per yard. What did the whole amount to?
Ans. $44.890'.

18. How many yards of carpeting, which is $\frac{7}{8}$ of a yard wide, will be sufficient for a room 18 *ft.* 9 *in.* long, and 16$\frac{1}{2}$ *ft.* wide? *Ans.* 39$\frac{2}{7}$ yards.

19. A grocer exchanged 12 *cwt.* 3 *qr.* 18 *lb.* sugar, at 7.18\frac{3}{4}$ per *cwt.*, for wheat at 81$\frac{3}{4}$ *cts.* per bushel. How many bushels of wheat were required to pay for the sugar?
Ans. 113.505' bushels.

20. A gentleman has a flower garden 30 *p.* 3 *yd.* in length, and 17 *p.* 4 *yd.* in breadth. Without altering the area, he wishes to increase the breadth to 20 poles; how much must the length be diminished? *Ans.* 3 *p.* 2$\frac{13}{22}$ *yd.*

21. If 5$\frac{3}{8}$ yards of cloth which is 3 *qr.* wide, cost $10.50, what ought to be paid for 14$\frac{1}{4}$ yards of cloth, of like quality, 5 *qr.* wide? *Ans.* $46.395'.

22. A and B barter as follows, viz., 4 *T.* 17 *cwt.* 3 *qr.* of hay, at $12 per ton, for corn at 1.87\frac{1}{2}$ per barrel. How many barrels of corn will be required as an equivalent for the hay?
Ans. 31$\frac{7}{25}$ barrels.

23. If the transportation of 15 *cwt.* 3 *qr.*, 100 miles, costs $45.50; what ought to be charged for the conveyance of 37 *T.* 1 *cwt.*, 400 miles? *Ans.* $8562.666'.

24. The sum of $500 is to be divided between A, B, and C, in such a manner that A's share shall be to B's as 5 to 3, and B's to C's as 3 to 7. What will be the share of each?
Ans. A's $166.666', B's $100, C's $233.333'.

25. If 5 laborers, working 8 hours a day, can dig a cellar 25 *ft.* long, 19 *ft.* wide, and 8 *ft.* deep, in 15 days, in what time ought 12 laborers, working 9$\frac{1}{4}$ hours a day, to dig a cellar 20$\frac{1}{2}$ *ft.* long, 17 *ft.* wide, and 8$\frac{1}{4}$ *ft.* deep? *Ans.* 4.089' days.

26. A person failing in business, is indebted to A $300, to B $250, and to C $400. His assets amount to $550: what will be the proportional share of each creditor?
Ans. A's $173.684', B's $144.736', C's $231.578'.

27. A merchant has coffee at 12 *cts.*, 16 *cts.*, and 18 *cts.*, a *lb.*, and wishes to form, of the different kinds, a mixture worth 14 cents a pound. What must be the ratios of the mixture?
Ans. 6 *lb.* at 12 *cts.*, 2 *lb.* at 16 *cts.*, and 2 *lb.* at 18 *cts.*

28. An estate consisting of 5000 acres of land, is to be divided among three persons, so that A's share shall be to B's as 2 to 5 and B's to C's as 3 to 8. Required the share of each.
Ans. A's 491$\frac{49}{61}$, B's 1229$\frac{31}{61}$, C's 3278$\frac{42}{61}$.

29. Allowing 2 *lb.* of tea to be worth as much as 13 *lb.* of coffee; and 5 *lb.* of coffee, as much as 9 *lb.* of sugar; and $20\frac{1}{2}$ *lb.* sugar, as much as 50 *lb.* of rice; how many pounds of tea will be equivalent to 100 *lb.* of rice? *Ans.* $3\frac{59}{117}$ *lb.*

30. How many gallons of brandy at 25 *cts.* per *gal.*, and how much water must be mixed with 5 gallons of brandy at 40 *cts.* per *gal.*, that the adulterated compound may rate at 30 *cts.* per *gal.*? *Ans.* $1\frac{3}{7}$ *gal.* of each.

31. A, B, and C form a partnership for 12 months. A and B at once advance $2500 each as their portion of the capital stock. At the end of 3 months C advances $3000; and B withdraws $1000. The profits amount to $1500: what is the share of each? *Ans.* A's $576.923', B's $403.846', C's $519.230'.

32. How many ounces of gold 18 carats fine, must be compounded with 5 *oz.* 23 carats fine, and 8 *oz.* 22 carats fine, that the compound may be 20 carats fine? *Ans.* $15\frac{1}{2}$ ounces.

33. In a joint speculation, A had $\frac{1}{4}$ of the capital for 6 months, B $\frac{2}{5}$ of it for 9 months, and C the remainder for 12 months. The loss amounted to $500: what loss should be sustained by each?

Ans. $80.645' by A, $193.548' by B, $225.806' by C.

34. A merchant has four kinds of coffee, worth, respectively, 8 *cts.*, 12 *cts.*, 14 *cts.*, and 20 *cts.* per *lb.* What quantity of each kind must be taken to form a mixture of 100 pounds, which shall rate at 15 *cts.* per pound?

Ans. $42\frac{4}{13}$ *lb.* at 20 *cts.*, $19\frac{3}{13}$ *lb.* at each of the other rates.

35. The sum of $3000 is to be divided between A, B, C, and D in such a manner that A's share shall be to B's as $2\frac{1}{2}$ to 3; B's to C's as 3 to 4, and C's to D's as 5 to 6. What will be the share of each? *Ans.* A's $524.475', B's $629.370', C's $839.160', D's $1006.993'.

36. If 20 bushels of wheat be worth $37\frac{1}{2}$ *bu.* of rye, and $3\frac{1}{2}$ *bu.* of rye be worth 1 barrel of corn, and 2 barrels of corn be worth 9 *bu.* of oats, and 25 *bu.* of oats be worth 1 ton of hay; how many tons of hay should be exchanged for 100 bushels of wheat? *Ans.* $9\frac{9}{14}$ tons.

CHAPTER X.

PERCENTAGE, AND ITS APPLICATIONS.

PERCENTAGE.

§ 244. *Percentage* is an allowance at a certain rate for *every hundred.*

The Latin *per centum*, or its contraction, *per cent.*, signifies *by the hundred.*

One per cent. on any number is *one* for *every hundred; two per cent.* is *two for every hundred;* and so on.

One per cent. on any sum of money is $1 for every $100; *two per cent.* is $2 for every $100; and so on.

What is meant by 3 *per cent.?* By 4 per cent.? By 6 per cent.?
How much is 1 per cent. on $100? On $200? On $400?
How much is 2 per cent. on $100? On $300? On $500?
How much is 3 per cent. on $100? On $400? On $700?

Ratio of Percentage.

§ 245. The *ratio of percentage* is the rate per cent. divided by 100. It is usually expressed *decimally*, by making two *integral* figures *decimals* in the rate per cent.—prefixing 0s when necessary.

Thus 1 per cent. on any number is $\frac{1}{100}$, or .01, of that number; the fraction $\frac{1}{100}$, or .01, being the *ratio* of percentage for 1 per cent.

What is the *ratio* for 2 per cent.? For 3 per cent.? For 4 per cent.? For 5 per cent.? For 6 per cent.? For 10 per cent.?

§ 246. When the rate per cent. is a *mixed number*, or a proper *fraction*, the ratio of percentage will be a *mixed fraction*, which may be reduced to a simple fraction.

Thus the ratio for 2½ per cent. is $\frac{2\frac{1}{2}}{100}=.02\frac{1}{2}=.025$; and the ratio for ¾ per cent., that is, ¾ of 1 per cent. is $\frac{\frac{3}{4}}{100}=.0075$.

What is the ratio for ½ per cent.? For ¼ per cent.? For 1½ per cent.? For 1¼ per cent.? For 2¾ per cent.? For 5¼ per cent.?

§ 247. The *ratio* of percentage multiplied by 100 produces the *rate per cent.* Thus the ratio being .03, the rate per cent. is $.03 \times 100 = 3$.

The rate per cent. is readily found from the decimal ratio, by making two *decimal* figures in the ratio *integral.*

Thus the ratio being .0125, the rate per cent. is $1.25 = 1\frac{1}{4}$.

If the ratio is .01, what is the rate per cent.? If the ratio is .02? If the ratio is .015? If the ratio is .0225? If the ratio is .0375?

Basis of Percentage.

§ 248. The sum or number on which percentage is computed, at any given rate, may be called, for convenience, the *basis of percentage.*

Thus when we say, 2 per cent. on $300, the basis of percentage is $300.

If the rate per cent. is 2, and the amount of percentage $4, what is the *basis of percentage?* If the rate per cent. is 3, and the amount of percentage $9? If the rate per cent. is 4, and the amount of percentage $12? If the rate per cent. is 5, and the amount of percentage $20? If the rate per cent. is 6, and the amount of percentage $30?

PERCENTAGE ON A GIVEN NUMBER.

RULE XLIX.

§ 249. *To find an* AMOUNT OF PERCENTAGE *on a given number.*

Multiply the given number, or *basis* of percentage, by the *ratio of percentage;* the product will be the *amount* of percentage.

EXAMPLE.

To find 5 per cent. on $150.

The *ratio* of percentage is $\frac{5}{100} = .05$. (§ 245).

Then $\$150 \times .05 = \$7.50$, the amount of percentage.

Observe that 5 per cent. on $150, is $\frac{5}{100}$ of $150, and multiplying by a fraction finds such a part of the multiplicand as is expressed by the multiplier.

By PROPORTION. $100 : $150 :: $5 : Amount of percentage.

From a given Amount of Percentage, to find the Basis of Percentage.

From the preceding Rule it follows, that

§ 250. The amount of percentage divided by the *ratio* of percentage, gives the basis of percentage.

INSURANCE.

§ 251. Insurance is an obligation assumed by a company, or an individual, to pay for the *loss* or *damage* of property by fire, shipwreck, or other casualty.

The *Policy* is the certificate of insurance issued by the *Insurers*, sometimes called the *underwriters*, to the person *insured*.

The price or *Premium* paid for insurance is usually a specified percentum on the amount insured.

EXERCISES.

1. What would be the annual premium of insurance on a house, valued at $3500, at 1 per cent.? *Ans.* $35.

2. What would be the annual premium of insurance on a manufactory, valued at $20000, at 1½ per cent.? *Ans.* $300.

3. What would be the insurance on a shipment of goods amounting to $5200, from New York to New Orleans, at 1¼ per cent.? *Ans.* $65.

4. What would be the insurance on a ship and cargo, from New York to Liverpool, the ship being valued at $30000, and the cargo at $42000, at 1¾ per cent.? *Ans.* $1260.

5. The annual insurance on a paper mill, at 2 per cent., amounts to $165.50. What is the value insured?

Here the amount of percentage is given, to find the basis of percentage. (§ 250). *Ans.* $8275.

6. The policy of insurance on a shipment of cotton, at ¾ per cent, costs $75. What was the amount insured?
Ans. $10000.

7. A gentleman procures an insurance on his house and furniture, valued at $7500, at ⅝ per cent. per annum. What is the annual premium to be paid? *Ans.* $46.875.

8. The annual insurance on a manufactory, at 1¼ per cent., amounts to $250. What is the amount insured? *Ans.*

9. What would be the cost of insurance on a store house, valued at $5000, and a stock of goods amounting to $7500.50, at 2½ per cent.? *Ans.*

10. A steamboat is valued at $35000, and the proprietors of it obtain an insurance on ¾ of its value, at 3¼ per cent. Required the amount of premium to be paid? *Ans.* $853.125.

11. An upholsterer has his warehouse, valued at $8000, insured to the amount of ⅘ of its value, at 1½ per cent. per annum; and $10000 worth of furniture insured at 1¾ per cent. per annum. What does he pay for insurance annually?
Ans. $271.

DUTIES.

§ **252.** Duties, in commerce, are certain charges, imposed by Government, on articles imported from foreign countries. These duties are paid in the *Custom Houses* established in the several *ports of entry* of foreign trade.

A *specific duty* is a specified charge on the quantity; as on a *yard*, pound, gallon, &c., of the article.

An *ad valorem* duty is a specified percentum on the cost of the articles in the country from which they were imported (*Ad valorem* is a Latin phrase which signifies, *according to value.*)

An *invoice* is a written statement of articles and their cost.

Tare, Draft or Tret, and Leakage, are allowances made for the weight of the box or cask, &c., containing the articles; or for waste, leakage, &c., before the duty is computed.

12. What would be the amount of duty on an invoice of broadcloth amounting to $5465.75, at 30 per cent.? *Ans.* $1639.725.

13. What would be the amount of duty on an invoice of philosophical instruments, amounting to $30200, at 25 per cent.? *Ans.* $7550.

14. The duty on a box of goods, at 12½ per cent., amounted to $65; what was the amount of the invoice? *Ans.* $520.

15. A lot of cutlery was purchased in Sheffield for $575.18¾. What would be the amount of duty on it at 9½ per cent.? *Ans.* $54.642'.

16. An invoice of Irish linens paid a duty of $330. What was the amount invoiced, the duty being 33 per cent.? *Ans.* $1000.

17. A quantity of ready-made clothing was purchased in Paris for $1534.12½. What would be the amount of duty to be charged, at 15 per cent.? *Ans.* $230.118'.

18. An invoice of silk was purchased in Canton for $12000.25, what is the amount of duty to be paid, at 10 per cent.? *Ans.* $1200.025.

19. The duty on an importation of iron, at 20 per cent., amounted to $15000. For what sum then was the iron purchased abroad? *Ans.* $75000.

20. What would be the amount of duty to be paid on 3 *cwt.* 3 *qr.* 20 *lb.* of steel, purchased at $21.12½ per *cwt.*,—at 9 per cent.? *Ans.* $7.46'.

ONE GIVEN NUMBER A PERCENTAGE ON ANOTHER.

RULE L.

§ 253. *To find what* PERCENTUM *one given number is of another.*

Divide the number which is made the *percentage* by that which is made the *basis* of percentage. The quotient will be the *ratio* of percentage; and this quotient multiplied by 100, will produce the required *rate per cent.*

EXAMPLE.

To find what percentum $9 is of $150.

9÷150=.06, the *ratio* of percentage;

and .06×100=6, the required *rate per cent.* (§ 247).

This Rule follows from the preceding one. (§ 249).

Proportion. $150 : $100 : : $9 : the required *rate per cent.*

TAXES.

§ 254. TAXES are contributions in money, imposed by Government on property, and frequently on persons, for public purposes.

A *poll* or *capitation* tax is a tax on the person, without regard to property. A tax on property is sometimes *specific*, that is, a specified sum on certain articles; but it is most commonly *ad valorem*, or a specified *percentum* on the value.

EXERCISES.

21. A person paid a tax of $52.88¼ on $3525.50 worth of property; at what rate per cent. was the tax assessed? *Ans.* 1½ per cent.

22. The property of a town amounts to $50000, and the citizens resolve to tax it to the amount of $1125, for public improvements. At what percentum must the tax be laid? *Ans.* 2¼ per cent.

23. Allowing a gentleman to pay a tax of $1379.16⅔, on property amounting to $82750, at what rate per cent. is the tax assessed? *Ans.* 1⅔ per cent.

24. A citizen pays taxes as follows, viz: for three polls at $1.25; on a carriage $10; on silver plate valued at $500, 3 per cent.; on $15000 of other property, ¾ per cent. What amount of tax does he pay? *Ans.* $141.25.

25. The taxable polls in a State amount to 325830, and are assessed at $1.12½. The landed property in the State is valued at $38400000; at what percentum must the land be taxed, that the revenue from both sources may amount to $462558.75? *Ans.* ¼ per cent.

A Required Number, increased by a Percentum of itself, equal to a Given Number.

RULE LI.

§ 255. *To find a number which, increased by a specified* PER CENTUM OF ITSELF, *shall be equal to a given number.*

Divide the given number by 1 *plus* the *ratio of percentage:* the quotient will be the number required.

EXAMPLE.

What number, increased by 5 per cent. of itself, is equal to 210?

The *ratio of percentage* is .05; and 1+.05 is 1.05.

Then 210÷1.05=200, the *number required.*

Proportion. 100+5 : 100 : : 210 : the *number required.*

☞ The reason of the Rule is evident from considering that, as the *required number* multiplied by 1+ the *ratio* of percentage, would be increased by the specified percentum of itself, and thus be equal to the *given number;* so the given number divided by 1+ the *ratio* of percentage, will give the required number.

In the example, 200×1.05=210, which is 200 increased by .05 of 200; then 210÷1.05 gives 200, the required number. ☜

COMMISSION.

§ 256. COMMISSION is a compensation to an Agent, Factor, or Commission Merchant, for buying or selling for another; and is usually reckoned at a certain percentum on the amount of purchase or sale. BROKERAGE is a commission charged by Brokers, or dealers in *money, stocks,* &c., on the amount of exchange, purchase or sale, which they effect for another.

EXERCISES.

26. An agent receives $500 to purchase goods—himself to retain a commission of 2 per cent. on the amount of purchase. What is the amount of purchase to be made? *Ans.* $490.196’.

27. A factor receives a remittance of $1200 to purchase cloth, at a commission of 1¼ per cent. on the purchase. What will be the amount of purchase? *Ans.* $1185.185’.

28. A commission merchant sold goods amounting to $1785.81¼; at a commission of 1½ per cent. What sum must the merchant pay to the owner of the goods? *Ans.* $1759.025’.

29. An agent is intrusted with $450 to purchase iron. His commission being ¾ per cent. on the purchase, how many tons of iron can he buy at $30 per ton? *Ans.* 14.888’ *T.*

30. A, as factor for B, sells 50 bales of cotton, averaging 450 pounds, at 7½ *cts*. per *lb*.—commission 1¾ per cent. With the proceeds A purchases for B, a supply of provisions,—commission ½ per cent. on the purchase. What sum is expended for provisions? *Ans*. $1649.71'.

A Required Number, diminished by a Percentum of itself, equal to a Given Number.

RULE LII.

§ **257.** *To find a number which, diminished by a specified percentum of itself, shall be equal to a given number.*

Divide the given number by 1 *minus* the *ratio of percentage;* the quotient will be the number required.

EXAMPLE.

What number diminished by 5 per cent. of itself, is equal to 190?

The ratio of percentage is .05 ; and 1—.05 is .95.

Then, 190÷.95=200, the *number required.*

Proportion. 100—5 : 100 : : 190 : the *number required.*

☞ The reason of the Rule is evident from considering that, as the *required number* multiplied by 1 *minus* the *ratio* of percentage, would be diminished by the specified per centum of itself, and thus be equal to the *given number;* so the given number divided by 1 *minus* the *ratio* of percentage, will give the required number.

In the example, 200×1—.05=190, which is 200 diminished by .05 of 200; then 190÷1—.05 or .95=200, the required number. ☜

STOCK.

§ **258.** STOCK, or *Capital*, is money or other property employed in any way to produce a profit; as in manufactures, banking, &c. Bonds of the Government are also called Government Stock.

The stock of a Company is divided into shares, usually of $100 each; and the owner of one or more shares is called a *Stockholder*.

The *nominal value*, or *par* value of a share of stock, is its *first cost*, or the sum originally invested in it.

Stock is said to be *above par*, at a *premium*, or an *advance*, when it sells for more than its nominal value; and *below par*, or at a *discount*, when it sells for less than its nominal value.

The rise or fall of stock is expressed by a *percentum* on its *nominal or par value.*

EXERCISES.

31. When bank stock sells at $5\frac{1}{2}$ per cent. below par, what nominal amount of stock can be bought for $945 ?

The nominal amount is such, that, when diminished by $5\frac{1}{2}$ per-centum of itself, it will be equal to $945. *Ans.* $1000.

32. When rail road stock sells at a discount of $7\frac{1}{2}$ per cent., what nominal value of it can be bought for $2775 ?

Ans. $3000.

33. What nominal amount of stock in an insurance office, at an advance of 5 per cent., can be purchased for $2100 ? and what amount in another, at a discount of 5 per cent., can be purchased for $1900 ? *Ans.* $2000 in each.

34. What amount of stock in the capital of a manufacturing company, at a discount of $3\frac{1}{2}$ per cent., can be purchased for $1930 ? and what amount in another, at an advance of 4 per cent., can be purchased for $3120.

Ans. $2000 ; and $3000.

35. A merchant ships, from New York to Charleston, a stock of goods amounting to $5000. He wishes to insure for a sum which shall cover both the value of the goods, and the premium for insurance. For what amount must the policy be taken, at $\frac{1}{2}$ per cent.?

The amount of the policy, diminished by $\frac{1}{2}$ per cent. of itself, will be $5000. *Ans.* $5025.125'.

36. A manufactory valued at $2500, is insured, at $1\frac{1}{4}$ per cent., in such a sum, that, in case of a total destruction of the establishment, the proprietors may claim, at the insurance office, the value of the property, together with the premium paid for insurance. What was the amount insured ?

Ans. $2531.645'.

PERCENTAGE OF PROFIT AND LOSS.

The preceding Rules of Percentage are applicable to various questions relating to *profit* and *loss* in trade. This application of the subject will be seen in the following Exercises.

It must be carefully observed that,

§ 259. In calculating the Percentage of Profit, or Loss, in trade, —— the *cost* of the commodity is always regarded as the *basis* of percentage (§ 248).

The amount of Profit or Loss found from the Cost, and the percentum of Profit or Loss.

§ 260. The amount of profit or loss is the amount of percentage on the cost, at the given *rate* per cent. of profit or loss. (§ 249).

When the rate per cent. is an aliquot part of 100, the amount of percentage will often be found, most readily, by taking *such part of the cost*, or basis of percentage.

EXERCISES.

1. A merchant bought a quantity of cloth for $330, and sold the same at a profit of 33⅓ per cent. What amount of profit did he make.

The amount of profit is $330×.33⅓; or since the rate per cent. 33⅓ is ⅓ of 100, the answer will be found, more readily, by taking ⅓ of $330. *Ans.* $110.

2. A grocer bought a hogshead of sugar for $55.75, and sold it at a profit of 12½ per cent. What amount of profit did he make? 12½ is ⅛ of 100. *Ans.* $6.968'.

3. A merchant bought silk for $160, and, on account of its becoming damaged, sold it at a loss of 5½ per cent. What amount of loss did he sustain? *Ans.* $8.80.

4. A flour dealer bought 130 barrels of flour, at $4.12½ per barrel, and sold it at a profit of 10 per cent. What amount of profit did he make? *Ans.* $53.625'.

5. A person purchased 25 barrels of dried apples, at $2.12½ per barrel. On account of damage received, he must sell them at a loss of 15 per cent.; what amount of loss will he sustain? *Ans.* $7.968'.

6. A grocer purchased 100 *gal.* 3 *qt.* of wine, at $.61¼ per gallon. He sold one half of the wine at a profit of 40 per

cent., and the other half at a profit of $33\frac{1}{3}$ per cent.; what amount of profit did he make? *Ans.* $22.625'.

The price in selling found from the Cost, and the percentum of Profit or Loss.

§ 261. The price in selling at a *profit* is equal to the cost + the percentage on the cost; and the price in selling at a *loss* is equal to the cost *minus* the percentage on the cost. (§ 249).

7. A farmer bought land at $44.75 per acre, and immediately sold it at an advance of 25 per cent. At what price per acre was the land sold? *Ans.* $55.937'.

8. A quantity of Irish linen was bought at $.$62\frac{1}{2}$ per yard; but, becoming damaged, is to be sold at a loss of $12\frac{1}{2}$ per cent. Required the selling price per yard? *Ans.* $.$54\frac{11}{16}$.

9. A manufacturer sold cotton cloth at a profit of 20 per cent. on the cost of making it, which was $.$12\frac{1}{2}$ per yard. At what price was the cotton sold? *Ans.* $.15.

10. A grocer purchased coffee at $10.50 per *cwt.* From a depreciation in value, the coffee must be sold at a loss of $3\frac{1}{2}$ per cent. What will be the selling price per *cwt.*? *Ans.* $10.132'.

The Cost found from the amount of Profit or Loss, and the percentum of Profit or Loss.

§ 262. The cost is the sum or basis on which the amount of profit or loss is the specified *per centum.* (§ 250.)

11. By selling a lot of iron at an entire profit of $22.50, I made 9 per cent. on the cost. What did I pay for the iron? *Ans.* $250.

12. An agent sold a consignment of flour at a profit of $.35 per barrel, which was 10 per cent. on the cost. What did the flour cost per barrel? *Ans.* $3.50.

13. A merchant sold broadcloth at an advance of $33\frac{1}{3}$ per cent., and in so doing realized a profit of $2 per yard? What did the cloth cost him per yard? *Ans.* $6.

14. A commission merchant sold a consignment of hats at a loss to the manufacturer of $12 per dozen, and 25 per cent. What was the cost per dozen to the manufacturer? *Ans.* $48.

15. A speculator purchased a quantity of pickled pork, which he disposed of at a profit of 20 per cent.—this being a profit of $2.50 per barrel. What did he pay per barrel? *Ans.* $12.50.

16. A broker purchased railroad stock for $450 less than its nominal value; and that was at a discount of 9 per cent. What was the par value of the amount of stock purchased?
Ans. $5000.

The percentum of Profit or Loss found from the Cost, and the amount of Profit or Loss.

§ **263.** The percentum of profit or loss is the percentum that the amount of profit or loss is of the *cost*, regarded as the basis of percentage. (§ 253).

17. If silk were purchased at $1.50 per yard, and sold at $2 per yard, what would be the gain per cent.?
Ans. 33⅓ per cent.

18. If a lot of books be purchased at $2.50 per dozen, and sold at $3 per dozen, what will be the gain per cent.?
Ans. 20 per cent.

19. A merchant bought hats at $36 per dozen, and sold them at $4.62 apiece. What was his gain or loss per cent.?
Ans. Gain 54 per cent.

20. A shop-keeper bought shoes at $18.75 per dozen, and sold them at $1.37½ a pair. What was his percentum of profit or loss. *Ans.* Loss 12 per cent.

If the shoes had been sold at $1.93¾ a pair, what would have been the percentum of profit or loss?
Ans. Profit 23.733' per cent.

The Cost found from the Price in selling and the percentum of Profit or Loss.

§ **264.** The cost is such that, when increased by the specified percentum of itself, it will equal the price in selling at a *profit;* or diminished by the specified percentum of itself, will equal the price in selling at a *loss.* (§ 255 and § 257).

21. A grocer sells sugar at $.12½ per *lb.*, and in so doing makes a profit of 25 per cent. What did the sugar cost per pound? *Ans.* $.10.

22. A merchant sold a lot of damaged flour at $3.75 per barrel,—sustaining a loss of 12½ per cent. What did the flour cost per barrel? *Ans.* $4.285.

23. A drover sold a lot of cattle for $900; which was 20 per cent. more than he gave for them. What did he pay for them? *Ans.* $750.

24. What does a shop-keeper pay for tea, when, by selling it at $1.25 per pound, he makes a profit of 25 per cent.? *Ans.* $1.

25. A manufacturer sold a lot of shoes for $400; which was 33⅓ per cent. advance on the cost of making them. What amount of profit did the manufacturer realize? *Ans.* $100.

26. A gentleman sold his stock of household furniture for $3200.50; which was at a loss of 22½ per cent. on the cost of it. What amount of loss was sustained on the furniture? *Ans.* $929.177'.

27. A merchant bought a piece of cloth containing 34 *yd.* 3 *qr.*, at $4.87½ per yard, and sold the same at a profit of 30 per cent. What amount of profit did he make? *Ans.* $50.821'.

28. An upholsterer bought a piece of carpeting containing 41 *yd.* 3½ *qr.*, at $1.12½ per yard. For what sum must he sell the whole to realize a profit of 33⅓ per cent.? *Ans.* $62.812'.

29. A grocer having sold a lot of liquors for $375.50, finds that his profit is at the rate of 25 per cent. For what sum were the liquors purchased?

The cost is such that, when increased by 25 per cent. of itself, it is equal to $375.50. *Ans.* $300.04'.

30. A speculator sold a quantity of flour for $800.25, and found that he had sustained a loss on it of 3½ per cent. For what sum was the flour purchased? *Ans.* $829.274'.

31. A manufacturer made 300 *yd.* 2½ *qr.* of woolen cloth, at a cost of $3.18¾ per yard. For what sum must the whole be sold to clear 15 per cent.? *Ans.* $1101.748'.

32. A farmer bought a tract of land for $3000. Having put improvements on the land at an expense of $735.37½, for what sum must the whole property be sold to realize a gain of 20 per cent.? *Ans.* $4482.45'.

33. A merchant bought 30 *yd.* of silk at $.87½ per yard. Having sold one half of the silk at $1.25 per yard, what will be his percentum of profit on the whole if the other half be sold at $1.18¾ per yard? *Ans.* 39.285' per cent.

34. Sold a quantity of bacon at $.12½ per pound, and in so doing made a profit of 25 per cent. If it had been sold at $.09 per pound, what would have been the percentum of profit or loss? *Ans.* 10 per cent.

First find the cost, and thence the percentum of profit or loss at the latter price. *Ans.* 1 per cent.

EXERCISES ON CHAPTER X.

1. A person insured his house and furniture in the sum of $5000, for five years, at 2¼ per cent. annually. What amount of premium did he pay? *Ans.* $562.50.

2. An invoice of foreign manufactured articles, amounting to $1300.87, is chargeable at the custom house with a duty of 20 per cent. What is the amount of duty to be paid? *Ans.* $260.174.

3. The tax on a certain landed estate amounts to $734.25. What is the estimated value of the estate, the tax being levied at ¾ per cent.? *Ans.* $97900.

4. A broker's commission on a purchase of bank bills amounting to $1000, was $2.50. At what percentum was commission charged? *Ans.* ¼ per cent.

5. An agent receives $3000 to purchase merchandise,—1¼ per cent. on the amount of purchase to be retained. What amount of purchase can the agent make? *Ans.* $2962.50.

6. What nominal amount of stock in the capital of a road company, at 10½ per cent. below par, could be bought for $1342.50? *Ans.* $1500.

7. A merchant bought 75 yards of cloth for $262.50. Its transportation cost $5.18¾, and the insurance on its transportation ¼ per cent. At what price per *yd.* must it be sold to clear 33⅓ per cent.? *Ans.* $4.770'.

8. The property of a city amounting to $5000000, is to be taxed to the amount of $100000, for the purpose of constructing a railroad. At what percentum must the tax be laid? *Ans.* 2 per cent.

9. Bought a quantity of wheat for $700.62½. Paid for transportation, and other charges on it $43.06¼; and sold it at a profit of 15 per cent.; what was the amount of profit made? *Ans.* $111.553.

10. A grocer bought coffee at $.10 per pound, and sold the same at $.12½ per pound. What percentum of profit did he make on the coffee? *Ans.* 25 per cent.

11. A merchant sold a lot of cloth at $6.50 per yard, and thus realized a gain of 25 per cent. If the cloth had been sold at $5 per yard, what would have been his percentum of gain or loss? *Ans.* 3 11/13 per cent. loss.

12. Find the amount of stock in an insurance office, at 10 per cent. advance, that could be bought for $440, and the amount in a canal company, at 10 per cent. discount, that could be bought for $1000. *Ans.* $400; and $900.

13. A bought 200 head of cattle, for $1700. He sold to B one fourth of the number, at $13.25, and the remainder to C,

at $15.37½ a head. What per centum of profit or loss did A realize on his cattle? *Ans.* Profit 74.632' per cent.

14. A commission merchant is to sell 12000 *lb.* of cotton, and invest the proceeds in sugar,—retaining 1¾ per cent. on the sale, and the same on the purchase. Cotton selling at 7 *cts.* and sugar at 5 *cts.*, a *lb.*, what quantity of sugar can the merchant buy? *Ans.* 16222.11' pounds.

15. On a stock of leather, sold at 18¾ per cent. profit, a merchant clears $237.50. At what cost was the leather bought? *Ans.* $1266.666'

16. A church which cost $20000, is insured at ¼ per cent., in such a sum, that, in case of its being destroyed by fire, the insurance company shall be liable for the cost of the building, and the premium of insurance. For what amount is the insurance taken? *Ans.* $20050.125'.

17. By selling a piece of damaged silk at $1.25 a yard, a merchant sustains a loss of 16⅔ per cent. At what price was the silk purchased, and what was the amount of loss on 20 yards? *Ans.* $1.50; and $5.

18. A broker purchased for another $3000 of canal stock, at an advance of 3 per cent.; and charged a commission of ¾ per cent. on the sum disbursed. What did the broker pay for the stock, and what is his commission? *Ans.* $3090; and $23.175.

19. A commission merchant sold a lot of cloth for $200; at a profit to the owner of 20 per cent. If the cloth ha been sold for $175, what would have been the percentum of profit or loss to the owner,—the commission in each case being 2 per cent.? *Ans.* Profit, 5 per cent.

20. Put into the hands of a broker $1000, in bank bills at a discount of 10 per cent. The broker was to purchase stock in the capital of a mining company, and have 1¼ per cent. on the nominal amount of the stock purchased. The stock is bought at 55 per cent. below par; what amount of brokerage do I have to pay? *Ans.* $25.

CHAPTER XI.

INTEREST.—DISCOUNT.—EQUATION OF PAYMENTS.—COMPOUND INTEREST.

INTEREST.

§ 265. INTEREST is the price or premium paid for the *use of money*, and is reckoned at a certain percentum, *annually*, on the sum for which it is paid.

Thus, if A lends B $500 at 6 per cent., for 3 years; at the end of that time, B must return the $500, and pay to A, as *interest*, $6 on each $100, for each of the 3 years.

The *Principal* is the sum for which Interest is paid—the *Amount* is the sum of the Principal and Interest.

What is the interest of $100, for one year, at 6 per cent.? For 2 years? For 3 years? For 5 years? For 9 years?

What is the interest of $200, for one year at 7 per cent.? For 3 years? For 4 years? For 8 years? For 10 years?

What is the amount of $100, for one year, at 6 per cent.? Of $200 for 2 years? Of $300 for 3 years? Of $1000 for 4 years?

Legal Interest.

§ 266. The *legal rate* of interest is the rate prescribed by law.

On debts in favor of the United States, interest is computed at 6 per cent.

In the individual States, the legal rate of interest is 6 per cent., with the exceptions that

In New York, South Carolina, Michigan, Wisconsin, and Iowa, it is 7 per cent.; in Georgia, Alabama, Mississippi, and Florida, it is 8 per cent.; in Texas, 10 per cent.; in Louisiana, 5 per cent., excepting that in the Louisiana banks it is 6 per cent.

Usury.

§ 267. *Usury* is any rate of interest above the rate *allowed by law.* The taking of usury is prohibited by law, in the different States, under various penalties; such as a forfeiture of double the usury, a forfeiture of the usury and a part of the debt, &c.

In some of the States, the law sanctions a rate of interest higher than the *prescribed legal rate*, when the higher rate has been stipulated for between the debtor and creditor. The limit to such stipulated rate of interest is usually 10 or 12 per cent.; but in the State of Wisconsin the law sanctions any rate which may be agreed upon between the parties.

RULE LIII.

§ 268. *To calculate* INTEREST *on any sum of money.*

1. Multiply the Principal by the *ratio* of percentage ; the product will be the interest for *one year.*

2. *Interest for any number of years* is found by multiplying one year's interest by that number.

3. *Interest for* MONTHS and DAYS may be found by taking proper *parts of one year's interest,*—in which case, reckon 12 months to a year, and 30 days to a month.

EXAMPLE.

Find the interest on $220.12½ for 4 *y.* 7 *m.* 10 *da.* at 6 per cent.

The *ratio of percentage* is .06 ; (§ 245).

	$220.125	
	.06	
The int. for 6 *m.* is ½ of	13.20750,	the int. for *one year.*
	4	
	52.8300	the int. for 4 *years ;*
" " for 1 *m.* is ⅙ of	6.6037'	" " for 6 *months ;*
" " for 10 *da.* is ⅓ of	1.1006'	" " for 1 *month ;*
	.3668'	" " for 10 *days.*
	$60.9011	" " for 4 *y.* 7 *m.* 10 *da.*

Finding the interest for *one year*, is the same as finding 6 per cent. on the principal ; (§ 249). The interest for 7 *m.* 10 *da.* is found by *aliquot parts ;* (§ 208).

The several parts of the interest added together, make the whole interest.

By *Compound Proportion.* The question may be stated thus:

If the interest on $100 for one year, be $6 ; what will be the interest on $220.12½, for 4 years, 7 months, and 10 days?

$$\text{Hence, } \left.\begin{array}{r} \$100 : \$220.12\tfrac{1}{2} \\ 1\,y. : 4\,y.\ 7\,m.\ 10\,da. \end{array}\right\} :: \$6 : \textit{Interest required.}$$

Note. In calculating interest for *months* and *days*, strict accuracy would require that the number of days in those months be taken, and 365 days allowed to a year. The method by the preceding Rule is commonly used, for convenience, though it allows but 360 days to a year.

EXERCISES.

1. A borrowed of B $500, at 6 per cent. interest, for 2 years, 5 months, and 12 days. What did the interest amount to? *Ans.* $73.50.

2. C loaned to D $750.50, for 1 year, 8 months, and 20 days, at 7 per cent. interest. What did the interest amount to? *Ans.* $90.476'.

3. Borrowed of my neighbor $175.25, at 6 per cent. interest. What amount will I owe him, if the money be kept 3 *y.* 11 *m.*? *Ans.* $216.433'.

4. Loaned to a friend $436.75, at 5 per cent. interest. What amount of money will discharge the debt, at the end of 1 *y.* 2 *m.* 15 *da.*? *Ans.* $463.136'.

5. An account with a merchant, amounting to $75.87½, bore interest, at 6 per cent., for 2 *y.* 4 *m.* 10 *da.* What sum was then required to pay off the principal and interest? *Ans.* $86.623'.

6. A farmer hired a laborer 12 months, for $125. Having deferred the payment of his wages for 3 *y.* 1 *m.* 25 *da.*, what amount should the farmer now pay, allowing interest at 6 per cent.? *Ans.* $148.645'.

7. Bought a plantation for $6000; of which one fourth is to be paid in hand, and the remainder in 2 *y.* 6 *m.*, with interest at 8 per cent. What will be the amount of the remainder, at the expiration of the credit? *Ans.* $5400.

8. A person buys a house for $3600, to be paid in 3 equal instalments, in one, two, and three years, with interest at 6 per cent. from the time of purchase. What will be the entire amount of principal and interest? *Ans.* $4032.

9. A speculator borrowed $5000, which he immediately invested in land, and in 6 months sold the land for $7500, on a credit of 12 months, with interest from the time of sale. Money being at 6 per cent. interest, what is the speculator's gain or loss at the end of the 12 *m.*; at which time he pays the $5000? *Ans.* Gained $2500.

10. A planter consigned to a commission merchant 45000 *lb.* of cotton, which the latter sold at 9½ *cts.* per *lb.*—commission ½ per cent. The proceeds due the planter were not paid until the expiration of 1 *y.* and 10 *m.*; what was the amount at that time, allowing interest at 7 per cent.? *Ans.* $4799.506'.

A Concise Method of Computing Interest at 6 per cent. for Months and Days.

Reckoning 12 months, of 30 days each, to a year.

§ 269. *To find the interest at 6 per cent. for a number of months*—multiply the principal in *dollars* by the number of months, and divide the product by 200; and

For a number of days—multiply the principal in dollars by the number of days, and divide the product by 6000.

The divisions may be abbreviated by rejecting the 0s from the divisors; (§ 152). The quotient, in each case, will be the interest in *dollars.*

EXAMPLES.

1. To find the interest of $50 for 11 months, at 6 per cent.

$50×11=$550; and $550÷200=$2.75.

The two integral 0s may be omitted in the divisor 200, if we make two integral figures *decimals* in the dividend $550.

We shall then have $5.50÷2=$2.75.

2. To find the interest of $50 for 19 days, at 6 per cent.

$50×19=$950; and $950÷6000=$.158'.

We may omit the three 0s in the divisor 6000, by making three integral figures *decimals* in the dividend $950.

We shall then have $.950÷6=$.158'.

3. The interest of 50 cents, for 11 *months*, would be

$.50×11÷200=$5.50÷200, or $.0550÷2,=$.027';

and for 19 *days*, it would be

$.50×19÷6000=$9.50÷6000, or $.00950÷6,=$.001'.

☞ The interest for 1 *year*, or 12 months, is $\frac{6}{100}$ of the principal; for *one month* it is $\frac{1}{12}$ of that, that is, $\frac{1}{12}$ of $\frac{6}{100}=\frac{6}{1200}=\frac{1}{200}$ of the principal; and the interest for 1 *m.* multiplied by the given number of months, will give the interest for that number of months; hence we find 200 for a *divisor,* and the given number of months for a *multiplier.*

Again. The interest for 1 *day* is $\frac{1}{30}$ of the interest for 1 *month,* that is, $\frac{1}{30}$ of $\frac{1}{200}=\frac{1}{6000}$ of the principal; and the interest for 1 *da.* multiplied by the given number of days, will be the interest for that number of days; hence we find 6000 for a divisor, and the given number of days for a multiplier. ☜

When the Rate of Interest is greater or less than 6 per cent.

§ 270. Having found the interest at 6 per cent., $\frac{5}{6}$ of that interest will be the interest at 5 per cent.; $\frac{7}{6}$ of it will be the interest at 7 per cent.; and in like manner for any other rate.

We may here remark that, as 365 days make a year, the interest found from allowing but 360 days to a year, is *greater than* the *true interest* in the same ratio in which 360 is less than 365.

360 is less than 365 by $\frac{5}{365}=\frac{1}{73}$ of 365 ; hence the interest found for days by the preceding methods, should be diminished by $\frac{1}{73}$ of itself for the true interest for the given time. These methods are, however, in general use ; and, having thus the general consent, are to be considered as correct.

By these methods perform the following

EXERCISES.

11. Find the interest on $54 for 6 *m.* 20 *da.*, at 6 per cent.

First find the interest for 6 *m.*, and then for 20 *da.*, and add the two together for the whole interest. *Ans.* $1.80.

12. Find the interest on $100 for 9 *m.* 18 *da.*, at 6 per cent.
Ans. $4.80.

13. Find the interest on $230 for 11 *m.* 15 *da.*, at 6 per cent.
Ans. 13.22\frac{1}{2}$.

14. Find the interest on $1234.75 for 120 *da.*, at 6 per cent.
Ans. 24.69\frac{1}{2}$.

15. Find the interest on $2300.25 for 137 *da.*, at 5 per cent.
Ans. $43.768'.

16. Find the interest on 4360.12\frac{1}{2}$ for 54 *da.*, at 5 per cent
Ans. $32.700'.

17. Find the interest on $1385.50 for 23 *da.*, at 7 per cent
Ans. $6.196'.

18. Find the interest on 3879.06\frac{1}{4}$ for 9 *da.*, at 7 per cent.
Ans. $6.788'.

19. Find the interest on 7351.18\frac{3}{4}$ for 13 *da.*, at 7 per cent.
Ans. $18.582'.

20. Find the interest on $2360.25 for 7 *m.*, at 8 per cent.
Ans. 110.14\frac{1}{2}$.

21. Find the interest on 1500.31\frac{1}{4}$ for 21 *da.*, at 6 per cent.
Ans. $5.251'.

22. Find the interest on 9000.87\frac{1}{2}$ for 17 *m.*, at 7 per cent.
Ans. $892.586'.

23. Find the interest on 8730.62\frac{1}{2}$ for 5 *m.* 23 *da.*, at 6 per cent.:—also at 5 per cent., and at 8 per cent.
Ans. $251.733'; $209.777'; $335.644'.

When the Time of Interest is the Interval between two Dates.

§ 271. When the time for which interest is to be computed, is the interval between two given dates, it is customary to include only one of those two days in the time of interest.

The interval found by the method of § 195, will be the proper one, since that interval will include but one of the days of the two given dates. (§ 196).

When the time is *years, months,* and *days,* we may employ the method of Rule LIII, or find the interest for the *months,* and *days,* by § 269, § 270, and add such interest to that found for the given number of *years.*

24. What is the interest on $250 from January 15th, 1840, to June 10th, 1842, at 6 per cent.? *Ans.* $36.083'.

25. What is the interest on $192.25 from February 20th, 1841, to May 12th, 1843, at 5 per cent.? *Ans.* $21.361'.

26. What is the interest on $370.12½ from September 5th, 1842, to December 1st, 1845, at 7 per cent.? *Ans.* $83.915'.

27. What is the interest on $500.18¾ from October 28th, 1844, to January 16th, 1847, at 8 per cent.? *Ans.* $88.811'.

28 What is the interest on $734.62½ from November 13th, 1845, to August 29th, 1848, at 10 per cent.? *Ans.* $205.286'.

Partial Payments.

§ 272. No one method has been universally approved for computing the *remainder due* on a debt at interest, on which *partial payments* have been made.

The method which has been adopted by the Supreme Court of the United States, and by the courts in most of the individual States, may be stated thus:

Whenever a PAYMENT, or the AGGREGATE of *payments made,* will discharge the interest then due, add said interest to the principal, and from the amount subtract the payment, or the aggregate of payments up to that time.

The remainder is to be treated as a *new principal,* dating from the time of the last payment, and payments on this principal are to be credited as before; and so on.

Note. When no particular rate of interest is stipulated for between the debtor and creditor, it is understood that the *prescribed legal rate* (§ 266) at the *place where the debt is contracted,* is the one intended; as that is the only rate which, in such case, the law will enforce.

EXAMPLE.

$4000. *Washington, January* 1st, 1840.

On demand, I promise to pay to James Wealthy, Four thousand dollars, with interest at 6 per cent.; for value received.

John Ready.

This note was *endorsed* as follows:

July 1st, 1841, received $300
April 11th, 1843, recieved $700

Settlement was demanded, and full payment made, August 20th, 1845; what was the remainder or balance then due?

From the date of the note, January 1st, 1840, to that of the first payment, July 1st, 1841, was 1 *year* and 6 *months.* (§ 191).

Interest on $4000 for that time, at 6 per cent., $360.

The payment $300 was not sufficient to discharge the *interest then due.*

From the date of the note to that of the 2d payment, is 3 *y.* 3 *m.* 10 *da.*

Interest on $4000 for that time, $808.88.

The whole payment, $300+$700=$1000, up to the date of the 2d payment, will discharge the interest then due.

Adding the interest to the principal, $4000+$808.88=$4808.88.

Subtracting the whole payment made, from the amount, we find $3808.88, for a *new principal,* dating April 11th, 1843.

Amount of $3808.88 from April 11th, 1843, to August 20th, 1845,—which was the balance due at the time of settlement.—$4347.836'.

Were there other payments on the note, we should treat them and the new principal according to the same method.

EXERCISES.

$950. *Philadelphia, June* 26th, 1844.

29. On the first day of January next, I promise to pay to Timothy Friend, Nine hundred and fifty dollars, with interest; for value received. *Jacob Faithful.*

This note is endorsed as follows:

March 20th, 1845, received $430.
May 15th, 1845, received $234.75.

What was the balance due, June 1st, 1846?

Ans. $353.172'.

$3000. *New York, May* 1st, 1845.

30. Six months after date, I promise to pay to John Prosperous, Three thousand dollars, with interest; for value received.

William Needy.

The endorsements on this note are as follows:

November 1st, 1845, received $1000.
October 10th, 1846, received $93.75.
December 20th, 1847, received $300.50.

What was the balance due, January 1st, 1848?

Ans. $2030.23'.

Rate per cent., or Time of Interest—how found.

§ **273.** The *Rate per cent. is found* by dividing the given Interest by the interest of the Principal, at 1 per cent., for the given Time; and

The Time, in the denomination of *years, months*, or *days, is found* by dividing the given interest by the interest on the principal for *one year*, month, or day, respectively.

☞ These methods are evident from considering, *first*, that, as the interest at 1 per cent. × any given *rate*, would produce the interest at that rate; so the given interest ÷ the interest at 1 per cent., will give the required rate; and

Secondly, that, as the interest for 1 year, &c., × the given time, produces the interest for that time; so the given interest ÷ the interest for 1 year, &c., will give the required time. ☜

EXERCISES.

31. At what rate per cent. must $250 be put at interest, to amount to $287.50, in 2 *yr.* 6 *m.*?

The given interest is $287.50—$250=$37.50.

Ans. 6 per cent.

32. In what time will $300 amount to $373.50, if the rate of interest be 7 per cent.? *Ans.* 3 *yr.* 6 *m.*

33. At what rate per cent. must $1000 be put at interest, to amount to $1120, in 1 *yr.* 6 *m.*? *Ans.* 8 per cent.

34. In what time will $$475.37\frac{1}{2}$ amount to $532.42, if the rate of interest be 6 per cent.? *Ans.* 2 years.

35. In what time will $100, or any other principal, double itself, if put on interest at 6 per cent.? and in what time would it double itself, at 7 per cent.?

Ans. $16\frac{2}{3}$ years; and $14\frac{2}{7}$ years.

36. A loaned to B $200 for 2 *yr.* 7 *m.* 25 *da.* At the end of that time B paid the debt, and loaned to A $150 until he received from A as much interest as he had paid him; how long did A keep the money? (*It is immaterial what was the rate of interest.*) *Ans.* 3.537' years.

DISCOUNT.

§ **274.** Discount is a deduction from a debt due at a future time, without interest, on account of the *present payment* of the debt.

The *Present Worth* of such a debt, is that sum which, at interest, would *amount to the debt* by the time the debt becomes due; and the present worth subtracted from the future debt, leaves the *discount.*

For example, the rate of interest being 6 per cent., the *present worth* of $106 due in one year, without interest, is $100, since $100 would amount to $106 in one year; and the *discount* is $6.

The rate of interest being 6 per cent., what is the *present worth* of $112 due in 2 years, without interest? Of $118 due in 3 years? Of $224 due in 2 years? Of $336 due in 2 years?

The Present Worth corresponds with a Principal at interest, &c.

From the above it is evident that,

§ **275.** The present worth of a debt not due, and not bearing interest, may be regarded as a *principal;* the discount, as the *interest* on such principal for the time the debt has to run; and the debt itself, as the amount of such principal and interest.

RULE LIV.

§ **276.** *To find the* PRINCIPAL *when the Amount, Time, and Rate of interest are given.*

Divide the given amount by the amount of $1, found for the given time, at the given rate of interest: the quotient will be the principal required.

EXAMPLE.

A debt of $500 will be due in 3 years, without interest. What is the *present worth* of the debt, allowing the rate of interest to be 6 per cent.?

The required present worth is the principal of which $500 is the amount for 3 years, at 6 per cent.

The interest of $1 for 3 years, at 6 per cent., is 18 cents, and the amount $1.18.

Then $500÷1.18=$423.72, the principal or *present worth.*

☞ **The reason of the rule is evident from considering, that, as the amount of $1 *multiplied by* any principal, produces the amount of that principal for the same *time* and *rate* of interest; so, the *amount* of any principal *divided by* the *amount* of $1 for the same time and rate, will give that principal.** ☜

EXERCISES.

In finding the amount of $1, in the application of this Rule, let the decimal be extended to *four figures*, if it does not become *even* with two or three.

1. What principal would amount to $650 in 2 years, allowing the rate of interest to be 5 per cent.? *Ans.* $590.909'.

2. What is the present worth of $1000, payable in 1 year and 6 months, when money is worth 8 per cent. interest? *Ans.* $892.857'.

3. What principal would amount to $2500.75, in 3 years and 8 months, when the rate of interest is 6 per cent.? *Ans.* $2049.795.

4. What *discount* should be allowed for the present payment of $400, due in 3 years and 5 months,—interest at 6 per cent.? *Ans.* $68.05.

5. What would be the present worth of $3050, payable in 4 years and 9 months, when the rate of interest is 8 per cent.? *Ans.* $2210.144'.

6. A note for $750 will become due in 2 years, 3 months, and 20 days. What would be the discount for present payment, allowing money to be at 7 per cent. interest? *Ans.* $104.173'.

7. Sold property amounting to $3000, on a credit, without interest, of 12 months. What sum in hand would be an equivalent for the debt, allowing money to bring 8 per cent. interest? *Ans.* $2777.777'.

8. A note for $1200 has 1 year, 10 months, and 15 days to run, without interest. What sum in hand would be an equivalent for the note, supposing the rate of interest to be 6 per cent.? *Ans.* $1078.651'.

9. A merchant bought goods amounting to $4200, on a credit of 6 months, without interest. What sum in ready money would discharge the debt, allowing interest to be at 8 per cent.? *Ans.* $4038.461'.

10. A farmer sold a plantation containing 275 acres, at $30 per acre,—to be paid in two equal instalments, in one and two years, without interest. The purchaser immediately proposing

to pay an equivalent in ready money, what sum should the farmer receive, rating money at 6 per cent. interest?

Ans. $7574.544'.

Discount in Banks.

§ **277.** *Bank Discount* is the interest on a sum loaned, deducted at the time the loan is made.

A note on which money is borrowed from a bank, has usually from two to four months in which to *mature,* that is, become due. The time specified in the note is, by custom, extended three or four days, called *days of grace,* before payment is required.

The bank deducts the interest from the *face of the note,* or sum for which the note is given,—days of grace being included in the calculation; the remainder is the sum paid for the note, and is called the *avails* or *proceeds* of the note.

EXAMPLE.

A note for $500, payable in 60 days, is discounted in a bank, at 6 per cent. Required the *avails* of the note.

Adding three days of grace, the time is 63 *days.*

The interest on $500 for 63 days, is $5.25. This interest is the bank *discount.* Then $500—5.25=$494.75, the *avails of the note.*

The borrower receives $494.75 from the bank, and, at the end of the 63 days, must pay the bank $500.

It is sometimes desirable to know for what principal a note should be given, that the *avails* of it in bank shall be a given sum. Hence,

RULE LV.

§ **278.** *To find the Principal from which the Bank Discount deducted, will leave a* GIVEN SUM.

Divide the given sum by $1 *minus* the interest of $1 for the given time—days of grace included; the quotient will be the principal required.

EXAMPLE.

To find for what principal a note, payable in 60 days, must be given, that, when discounted in bank, at 6 per cent., the proceeds of it shall be $500.

The interest of $1 for 63 days is $.0105; and $1—$.0105 =$.9895.

Then $500÷.9895=$505.30', the principal required.

☞ The reason of the Rule appears from considering, that, as the *avails* of \$1 for the given time, *multiplied by* any principal, will produce the *avails* of that principal for the same time; so, the avails of any principal, *divided by* the avails of \$1 for the same time, will give that principal. ☜

EXERCISES.

In these Exercises add 3 days of grace to the time specified; and in finding the interest of \$1, in the application of this Rule, let the decimal be extended to *four figures*, if it does not become *even* with two or three.

11. What would be the proceeds of a note for \$1000, due in 90 days, if discounted in bank, at 6 per cent.? *Ans.* \$984.5.

12. A note for \$300, payable in 4 months, is discounted in bank, at 8 per cent. Required the sum received for it. *Ans.* \$291.8.

13. What would be the proceeds of a note for \$200.25, having 3 months, or 90 days, to run, if discounted in bank, at 6 per cent.? *Ans.* \$197.14'.

14. A note for \$430.50, payable in 60 days, is discounted in bank at 7 per cent. Required the amount of the discount. *Ans.* \$5.273'.

15. What would be the difference between bank discount and the true discount on a note for \$5000, payable in 4 months, or 120 days, reckoning interest at 6 per cent.? *Ans.* \$4.46.

16. A merchant wishes to borrow in bank \$2500, for 90 days. For what principal must his note be drawn, rating interest at 6 per cent.? *Ans.* \$2539.36'.

17. A person wishes to pay a debt of \$375.25, by having a note discounted in bank, for 60 days, at 6 per cent. For what sum must the note be made? *Ans.* \$379.231'.

18. A farmer owes a debt in bank of \$500. He pays the debt with a note payable in 3 months, which is discounted at 6 per cent.; and receives \$125.50 as the balance of proceeds of the note. For what amount was the note made? *Ans.* \$635.347'.

EQUATION OF PAYMENTS.

§ **279.** The *Equation of Payments* consists in reducing two or more different times at which payments of money are to be made, without interest, to one *equitable mean time* for the payment of the whole.

For example. A owes B $200 to be paid in 5 months, and $300 to be paid in 9 months; and it is required to find an *equitable mean* time for the payment of the whole $500.

RULE LVI.

§ **280.** *To find the proper period of credit for the sum of two or more payments due at different times, without interest.*

Multiply each payment not due by its own period of credit, and divide the sum of the products thus obtained, by the sum of all the separate payments. The quotient will be the time required.

The multipliers must all be used in the *same denomination* of time.

EXAMPLE.

A owes B $600; of which, $300 is to be paid in hand; $200 in 6 months; and the remaining $100 in 18 months. If the whole were reduced to *one payment*, what would be the proper *credit* to be allowed?

Multiplying the $200 by its credit, 6 months, we find 1200; and multiplying the $100 by its credit, 18 months, we find 1800.

The sum of these products is 1200+1800=3000.

Then 3000÷600, the sum of all the payments, gives 5 *months*, for the credit to be allowed on the $600.

☞ The period of credit for the *sum* of the payments, should be such that the discount on said sum, would be equal to the *sum* of the *discounts* on the separate payments, for their respective credits.

The preceding Rule proceeds on the supposition that the *discount* is equal to the *interest*, for the same time. The discount is, however, less than the interest; being the interest on the *present worth* of a debt, instead of the *principal*. The Rule is, therefore, inaccurate; though, for convenience, it is adopted in business.

In the preceding example,

The interest on $200 for 6 *m.* is the same as on $1 for 1200 *months*
and the interest on $100 for 18 *m.* is the same as on $1 for 1800 *months*

The whole interest involved is therefore equal to the interest on $1, for 1200+1800=3000 *months*; and the same interest would accrue on the $600 in 3000÷600=5 *months*.

Hence 5 months is the credit to be allowed on the sum $600. ☜

EXERCISES.

1. C is indebted to D $900; of which $200 will be due in 6 months; $300 more in 9 *m.*; and the remainder in 12 months. What would be the proper time for the payment of the whole at once? *Ans.* 9⅔ months.

2. A merchant bought goods amounting to $5000; of which he was to pay $3000 in hand, and the remainder in 6 months. It is since agreed that the whole shall be paid at one time; what is the proper credit to be allowed? *Ans.* 2⅖ months.

3. A certain sum of money was to be paid as follows, viz: ¼ of it in 2 years, ½ of it in 3 years, and the rest in 4 years and 6 months. The debtor proposing to pay the whole at the same time, it is required to find the proper term of credit.
Ans. 3⅛ years.

4. A engaged to pay to B, $200 on the 1st day of January; $300 on the 15th of April; and $400 on the 20th of August. They now agree to make but one payment of the whole, and wish to know on what day that payment will be equitably due.

The $200 was due on the 1st of January; when the $300 was entitled to a credit of 3 *m.* 15 *da.*, to the 15th of April; and the $400, to a credit of 7 *m.* 20 *da.*, to the 20th of August.

$$\$300\times(3\ m.\ 15\ da.)=\$300\times105\ da.=31500;$$
$$\text{and } \$400\times(7\ m.\ 20\ da.)=\$400\times230\ da.=92000.$$

Then $(31500+92000)\div(200+300+400)=123500\div900=137\frac{2}{9}$ *da.*

We thus find that the sum of the payments will claim a credit of $137\frac{2}{9}$ days, to be reckoned from the 1st of January.

Disregarding the $\frac{2}{9}$ of a day, and allowing 30 *days to a month*, we shall find that this credit will extend to the 17th of May.

5. On the 5th of September, 1846, a merchant bought goods amounting to $8000; of which $4000 was to be paid in 4 months, $2000 in 6 *m.*; and the remainder in 8 *m.* It was afterwards agreed that one payment might be made of the whole; what was the proper day of payment?
Ans. February 17th, 1847.

6. On the 10th of January, 1848, A bought of B, 100 acres of land, at $24 per acre,—to be paid in three equal instalments, on the 20th of October, 1848, the 1st of June, and 30th of December, 1849. If the whole be converted into one payment, on what day should that payment be made?
Ans. May 25th, 1849.

COMPOUND INTEREST.

§ 281. *Simple Interest* is interest on a given *principal* only; (§ 265). *Compound Interest* is interest on both *principal* and *interest,* when the *latter remains unpaid* after it has become due.

The interest is compounded *annually, half yearly,* or *quarterly,* &c., according to the time at which it becomes due.

Compound interest is not sanctioned, by law, on money lent, or debts contracted in ordinary commercial transactions.

§ 282. *To calculate Compound Interest.*—Make the *amount,* at simple interest, for the first year, or period when the interest becomes due, the *principal* for the second; the amount for the second, the principal for the third; and so on. From the *last amount* subtract the original principal; the remainder will be the compound interest.

EXERCISES.

1. What is the compound interest on $200, for 3 years, at 6 per cent., allowing interest to be due annually?

Ans. $38.203’.

2. What is the compound interest on $1000, for 2 years, at 8 per cent., allowing interest to be due half yearly?

Ans. $169.858’.

3. What would $500 amount to in 5 years, at 6 per cent. interest, if the interest be *compounded* annually?

Ans. $669.112.

EXERCISES ON CHAPTER XI.

$2500.18¾. *Philadelphia, June 1st,* 1845.

1. On the 1st day of January, 1846, I promise to pay to William Kind, the sum of Two thousand, five hundred dollars, 18¾ cents, with interest; for value received.

Simon Thankful.

This note was endorsed as follows:

January 1st, 1846, received $1000.
October 10th, 1846, received $35.25.
August 16th, 1847, received $200.

The balance on the note was not paid until the 1st of January, 1848. What amount was then to be paid?

Ans. $1541.40’.

2. A farmer bought of a merchant, goods amounting to $175.12½, on a credit of 12 months; but paid the debt in 2 months and 10 days. What sum should have been discounted from the debt, allowing the rate of interest to be 8 per cent? *Ans.* $10.596'.

3. A debt of $3000.75 will be due in 2 years, 7 months and 18 days, without interest. What sum in hand would be an equivalent for the debt, money being at 7 per cent. interest? *Ans.* $2533.775'.

4. A held a note against B for $473.50, due April 3d, 1846; and B held a note against A for $500.62½, due June 10th, 1846; no interest accruing in either case, until the note is due. Settlement was had May 5th, 1846; what was then the balance between A and B, allowing money to be worth 6 per cent.? *Ans.* A owed B $21.61'.

5. A merchant bought 43 *cwt.* 3 *qr.* of sugar, at $5.25 per *cwt.*, which he immediately sold at $7 per *cwt.*, on 6 months credit. Taking the purchaser's note for the amount, he gets the note discounted in bank, at 6 per cent.; what profit did the merchant make? *Ans.* $67.22'.

6. Wishing to raise the sum of $3760.50, I design, for the purpose, to put a note in bank for 4 months. For what principal must the note be drawn,—interest being at 8 per cent.? *Ans.* $3866.042'.

7. A promissory note for $350.75 was at interest from the 4th of July, 1844, to the 19th of January, 1847, when it had amounted to $404.238, at what rate was the interest computed? *Ans.* 6 per cent.

8. In what time will $400 produce the same amount of interest, at 6 per cent., that would acrue on $375.18¾, in 5 years, 7 months and 25 days, at 7 per cent.? *Ans.* 6.185' years.

9. A owes B $5000; of which $1200 is to be paid in 9 months, $3000 in 1 year and 3 months, and the remainder in 2 years. In what time might the whole sum be paid at once, without injustice to either? *Ans.* 15 months.

10. A rice plantation was to be paid for as follows, namely; ¼ of the purchase money in hand; ⅓ of it in 12 months; and the remainder in 1 year and 9 months. The parties have since agreed that the whole shall be paid at one time; when should the payment be made? *Ans.* In 12¾ months.

11. A money dealer borrowed $1000 for 2 years, at 6 per cent. interest; and loaned the same in such a manner as to *compound* the interest every 6 months. What profit did he make in the 2 years, by this proceeding? *Ans.* $5.508.

CHAPTER XII.

POWERS AND ROOTS.—INVOLUTION.—EVOLUTION.—APPLICATION OF SQUARE AND CUBE ROOT.

POWERS AND ROOTS.

§ **283.** The *first power* of a number is the number itself.

Thus, the *first power* of 3 is 3.

§ **284.** The *second power*, or *square*, of a number, is the product of that number *multiplied into itself.*

Thus, the *second power* or *square* of 3, is 3×3=9.

What is the second power, or square, of 4? Of 5? Of 7? Of 10?
What is the second power, or square, of 8? Of 11? Of 12? Of 20?

§ **285.** The *second root,* or *square root,* of a number, is that number which, multiplied into itself, produces the given number.

Thus the *square root* of 36 is 6, because 6×6=36.

What is the square root of 4? Of 25? Of 49? Of 64? Of 100?
What is the square root of 9? Of 16? Of 36? Of 81? Of 144?

§ **286.** The *third power*, or *cube*, of a number, is the product of that number multiplied into its second power, or square.

Thus the *third power*, or *cube*, of 3, is 3×3×3=27.

What is the third power, or cube, of 2? Of 4? Of 5? Of 7? Of 10?

§ **287.** The *third root*, or *cube root*, of a number, is that number which, being multiplied into its second power, or square, produces the given number.

Thus, the cube root of 27 is 3, because 3×3×3=27.

What is the cube root of 8? Of 64? Of 125? Of 216? Of 1000?

§ **288.** The *4th power* of a number is the product of that number multiplied into its 3d power, or cube. Thus, the 4th power of 2, is 2×2×2×2=16.

What is meant by the 5th power of a number? By the 6th power?

The *4th root* of a number is that number which, being multiplied into its 3d power, or cube, produces the given number; thus, 2 is the 4th root of 16.

What is meant by the 5th root of a number? By the 6th root?

From the preceding it is plain, that,

When one number is any *power* of another, the latter is the corresponding *root* of the former. Thus 9 is the *square* of 3; then 3 is the *square root* of 9.

Powers and Roots of Unity.

§ 289. Any *power* or *root* whatever, of *unity*, is *unity;* since any number of 1s, multiplied together, produce 1.

Thus, $1\times1=1$; $1\times1\times1=1$; and so on.

Powers and Roots of Fractions.

§ 290. A *power* or *root of a fraction* is found by taking the power or root of the *numerator* and *denominator*, separately.

Thus, the square of $\frac{2}{3}$ is $\frac{2\times2}{3\times3}=\frac{4}{9}$; and the square root of $\frac{4}{9}$ is therefore $\frac{2}{3}$. So the cube of $\frac{2}{3}$ is $\frac{8}{27}$.

What is the square of $\frac{3}{4}$? Of $\frac{5}{7}$? Of $\frac{7}{10}$? Of $\frac{5}{12}$?
What is the square root of $\frac{9}{16}$? Of $\frac{36}{49}$? Of $\frac{25}{100}$? Of $\frac{81}{121}$?
What is the cube of $\frac{3}{4}$? Of $\frac{2}{5}$? Of $\frac{5}{6}$? Of $\frac{4}{10}$?
What is the cube root of $\frac{8}{64}$? Of $\frac{27}{125}$? Of $\frac{125}{1000}$? Of $\frac{216}{1000}$?

Powers and Roots of Mixed Numbers.

§ 291. A power or root of *a mixed number* may be found by reducing to an *improper fraction*, and taking the power or root of the numerator and denominator, separately.

Thus, the *square root* of $5\frac{4}{9}=$ the square root of $\frac{49}{9}=\frac{7}{3}=2\frac{1}{3}$.

What is the square root of $2\frac{1}{4}$? Of $20\frac{1}{4}$? Of $11\frac{1}{9}$? Of $1\frac{11}{25}$?
What is the cube root of $3\frac{3}{8}$? Of $2\frac{10}{27}$? Of $1\frac{91}{125}$?

Perfect and Imperfect Powers.

§ 292. A *perfect power*, of any *order*, is a number which has an *exact root* of the corresponding order. An *imperfect power* has no exact root of the corresponding order. Thus,

A *perfect square*, or a *square number*, is any number, integral or fractional, which has an exact square root; and a *cube* number is one which has an exact cube root.

Name all the *square numbers*, in succession, from unity to the square of 12. Name several *cube numbers*, beginning with unity.

Name three fractions which are *perfect squares.* Name three which are *perfect cubes.*

An imperfect power is also called a *Surd;* and its root is called an *irrational* number, because its *ratio* to unity cannot be exactly determined.

Exponents of Powers and Roots.

§ 293. An *exponent* or *index* is an *integer* annexed to a number to denote a *power*, or a *fraction* annexed to denote a *root*, of that number.

Thus, 5^2 denotes the 2*d power* or square of 5.
5^3 denotes the 3*d power* or cube of 5.
$16^{\frac{1}{2}}$ denotes the *square root* of 16; $27^{\frac{1}{3}}$ the *cube root* of 27, &c.

In these expressions, 2, 3, $\frac{1}{2}$ and $\frac{1}{3}$ are *exponents*. An exponent is always set on the right of the number, and a little elevated, as in the examples.

A root is also denoted by the *radical sign* $\surd$, with an integral exponent or index.

Thus, $\sqrt{9}$ denotes the square root of 9; $\sqrt[3]{27}$, the cube root of 27; $\sqrt[4]{100}$, the 4th root of 100; and so on.

INVOLUTION.

§ 294. *Involution* consists in raising a given number to any required *power*. Thus, in finding the square of 25, we perform an *involution* on 25.

EXERCISES.

1. Find the square of .14. . . . . *Ans.* .0196
2. Find the square of .16. . . . . *Ans.* .0256.
3. Find the square of $\frac{19}{37}$. . . . . *Ans.* $\frac{361}{1369}$.
4. Find the square of $\frac{49}{163}$. . . . . *Ans.* $\frac{2401}{26569}$.
5. Find the square of $23\frac{1}{9}$. . . . . *Ans.* $534\frac{10}{81}$.
6. Find the square of 14.3. . . . . *Ans.* 204.49.

7. Find the cube of $\frac{5}{8}$. . . . . *Ans.* $\frac{125}{512}$.
8. Find the cube of 124. . . . . *Ans.* 1906624.
9. Find the cube of $13\frac{1}{4}$. . . . . *Ans.* $2326\frac{13}{64}$.
10. Find the cube of .25. . . . . *Ans.* .015625.

§ 295. A *higher power* of a given number may be found, most readily, by multiplying together two or more known powers, the *sum of whose exponents* is equal to the exponent of the *required power.*

Thus, the *square* of a number multiplied into itself, produces the 4th *power* of that number. $3^2\times3^2=3\times3\times3\times3=3^4$.

The *square* × the *cube*, produces the 5th *power*. $3^2\times3^3=3\times3\times3\times3\times3=3^5$; and so on.

11. Find the 4th power of $2\frac{1}{4}$. . . . . *Ans.* $25\frac{161}{256}$.
12. Find the 5th power of 3.5. . . . . *Ans.* 525.21875.
13. Find the 6th power of 1.2. . . . . *Ans.* 2.985984

EVOLUTION.

§ 296. *Evolution* consists in *extracting* any required *root* of a given number regarded as the corresponding *power* of the root to be found.

Thus, in extracting the square root of 625, we perform an *evolution* on 625.

The *extraction of the square root* of a number, consists in finding one of the *two equal factors* which, multiplied together, produce the given number.

Thus we find 25 to be the $625^{\frac{1}{2}}$, because $25\times25=625$.

Extraction of the Square Root

The following principles are involved in the Rule to be given for extracting the square root.

§ 297. I. The square of any number has, at most, only *twice as many* figures, and, at least, only *one less than twice* as many, as the number itself.

Thus, $9^2=81$; $99^2=9801$; $999^2=998001$; in which examples, the squares 81, &c., have only twice as many figures as the numbers 9, &c., and these numbers are the *largest that can be expressed* by the same number of figures.

Again; $10^2=100$; $100^2=10000$; $1000^2=1000000$; in which examples, the squares 100, &c. have only one less than twice as many figures as the numbers 10, &c., and these numbers are the *smallest that can be expressed* by the same number of figures.

From the preceding, it follows, that,

§ 298. II. A number has *two figures* for each figure in its *square root,* excepting the left hand one—for which it has one, or two figures, according as said left hand figure *produces one* or *two* figures in *squaring the root.*

§ 299. III. If a number be divided into *any two parts,* the *square of the number* will be equal to
the *square of the* 1*st part* + *twice the* 1*st* ×2*d* + the *square of the* 2*d part.*

For example, $16=10+6$, and the square of 16= the square of (10+6).

$$\begin{array}{r} 10+6 \\ \underline{10+6} \\ 60+36 \\ \underline{100+\ 60} \\ 100+120+36 \end{array} = \text{the square of } (10+6)=16^2.$$

In squaring $10+6$, that is, in multiplying it by itself, we first multiply $10+6$ by 6; this gives $60+36$ We then multiply $10+6$ by 10; which gives $100+60$. The sum of the two products is $100+120+36=16^2$.

This square is composed of $10^2=100$, *twice* $10\times6=120$, and $6^2=36$. Thus we see that the square of the number 16 is equal to the square of the first part 10, $+$ twice the product of the two parts 10 and 6, $+$ the square of the second part 6.

RULE LVII.

§ 300. *To extract the Square Root of a given number.*

1. Separate the given number into periods of two figures each, from right to left; observing that the last period may sometimes have but one figure.

2. From the left hand period subtract the greatest square number it contains, and set the root of said square for the first figure of the root required.

3. To the remainder affix the next period for a dividend. Divide this dividend, exclusive of its right hand figure, by twice the root already found, and annex the quotient figure to both the root and the divisor.

4. Multiply the divisor thus increased, by the quotient figure; subtract the product from the dividend; to the remainder affix the next period; divide by twice the root already found; and so on, till the operation is completed.

EXAMPLES.

1. To extract the square root of 529.

$$
\begin{array}{rl}
 & 5'29\,(23 \\
 & \underline{4} \\
43) & 129 \\
 & 129 \qquad 529^{\frac{1}{2}}=23.
\end{array}
$$

The left hand period is 5, and the greatest square number it contains is 4, the root of which is 2. Subtracting, and to the remainder 1 affixing the next period, we have for a dividend 129. Excluding its right hand figure 9, we divide 12 by 4, which is *twice* the root 2 already found, and annex the quotient figure 3 to both the root and the divisor. Multiplying the divisor 43 by 3, completes the operation.

2. To extract the square root of 368449.

```
            3 6'8 4'4 9(6 0 7
            3 6
1 2 0 7)      8 4 4 9
              8 4 4 9
```

$368449^{\frac{1}{2}}=607$.

The left hand period 36 being a square number, we set its root 6 for the first figure in the root required; and set down the next period 84, for a dividend.

Excluding its right hand figure 4, and dividing 8 by 12, which is *twice* the root 6 already found, the quotient is 0, which we annex to the root 6 and divisor 12.

To 84 we affix the next period 49, and the dividend is 8449. Excluding its right hand figure, and dividing by 120, which is *twice* the root 60 already found, the quotient is 7. Annexing this to the root and divisor, and multiplying, the operation is completed.

☞ The given number is separated into periods to determine the number of figures in the root; and also whether one or two figures on the left correspond to the first figure in the root; (§ 298). In the first example,

The first figure 2 in the root is 2 *tens* =20, and its square is 400; which, subtracted, leaves the remainder 129.

The given number 529= the square of 2 *tens*, the 1*st part* of its root, + *twice* 2 tens × the *units* or 2d part of the root, + the *square* of the units. (§ 299).

And since the square of 2 tens has been subtracted, the remainder 129 = twice 2 *tens* × the *units* + the *square* of the units.

In taking 4,= twice 2, for a divisor, we omitted the 0 on the right of 2 tens. Omitting, therefore, the 9 in the corresponding place of the dividend 129, we say 4 in 12, 3 times.

The quotient 3 annexed to the 4 in the divisor, makes the 4 become 4 *tens;* and the divisor 4 *tens* +3, multiplied by 3,=4 *tens* $\times 3+3^2$; or twice 2 tens × the *units* in the root, + the *square* of the *units*, =129.

Hence the second figure in the root is correctly found by the Rule.

When the given number contains three or more periods, the first and second figures of the root having been found, these two figures together may be regarded as the 1st part of the entire root, and the remainder of the root as the 2d part. Three figures of the root having been found, these may together be regarded as the 1st part of the root, and the remainder as the 2d part; and so on.

Under these views, the principle on which depends the method of forming the divisors, (§ 299), becomes applicable when there are three or more, as well as when there are but two figures in the root. ☜

EXERCISES.

1. Find the square root of 784, and of 11236.
Ans. 28; and 106.
2. Find the square root of 2025, and of 38809.
Ans. 45; and 197.
3. Find the square root of 7396, and of 75076.
Ans. 86; and 274.
4. Find the square root of 22801, and of 473344.
Ans. 151; and 688.
5. Find the square root of 36100, and of 904401.
Ans. 190; and 951.
6. Find the square root of $\frac{256}{289}$, and of $\frac{1156}{5041}$.
Ans. $\frac{16}{17}$; and $\frac{34}{71}$.
7. Find the square root of $\frac{6561}{9025}$, and of $\frac{10000}{39204}$.
Ans. $\frac{81}{95}$; and $\frac{100}{198}$.
8. Find the square root of $\frac{5929}{7056}$, and of $\frac{11881}{94864}$.
Ans. $\frac{77}{84}$; and $\frac{109}{308}$.
9. Find the square root of $\frac{1024}{1089}$, and of $\frac{1225}{1296}$.
Ans. $\frac{32}{33}$; and $\frac{35}{36}$.
10. Find the square root of $\frac{8281}{8836}$, and of $\frac{9409}{10000}$.
Ans. $\frac{91}{94}$; and $\frac{97}{100}$.

Square Root of Decimals, Imperfect Squares, &c.

§ **301.** In extracting the square root, an *integer* is separated into periods from *right to left.*

A *decimal* must be separated into periods of two figures each, from the *decimal point towards the right,* and a 0 annexed when necessary to complete the last period.

The number of decimal figures in the root, will be equal to the number of *periods* in the given decimal.

In finding the root of an imperfect square, (§ 292), a period of 0s may be annexed to the last remainder, and the operation continued in this manner to any required exactness;—observing that each period thus annexed must be counted as a *decimal period* belonging to the given number.

A fraction *will be an imperfect square,* if either of its terms is an imperfect square. Its root in such case will be found, most readily, by extracting the root of its *equivalent decimal.*

A *vulgar fraction annexed to an integer* may be reduced to a decimal, and the root of the mixed number be then extracted.

EXAMPLE.

To extract the square root of $346\frac{1}{8}$.

Reducing $\frac{1}{8}$ to an equivalent decimal, we find $\frac{1}{8}=.125$. We have then to extract the square root of 346.125.

```
          3'46.12'50(18.6044
          1
     28)246
          224
    366)2212
          2196
  37204)165000
          148816
 372084)1618400
          1488336
           130064
```

We separate the *integer* 346 into periods from *right* to *left*, and the *decimal* .125 into periods from the *decimal point towards the right*, and annex a 0 to complete the last period 50.

All the periods in the given number having been included in the operation, we annex 00 to the remainder, and thus continue the operation.

The two decimal periods .12'50, with the two periods of 0s annexed to the remainders, make *four decimal periods;* hence we make *four decimal figures in the root.*

☞ The product of two decimal fractions contains just as many decimal figures as are in both the factors. The *square* of a decimal fraction has, therefore, twice as many decimal figures as the decimal itself. Hence, each decimal *period* must contain *two figures;* and the number of *decimal figures* in the root must equal the number of *decimal periods.* ☜

§ **302.** In extracting the square root of an *approximate decimal*, such decimal should be continued to *twice as many figures* as the number of decimal figures required in the root.

For example, to extract the square root of $\frac{1}{3}$ to *three decimal figures.*

As $\frac{1}{3}$ is an *imperfect* square, we reduce it to a decimal of six figures.

$$\frac{1}{3}=.333333$$

The approximate decimal thus found, having three periods, will give three decimal figures in its square root.

EXERCISES.

11. Find the square root of .582169. . . . *Ans.* .763.
12. Find the square root of .454276. . . . *Ans.* .674.
13. Find the square root of .795664. . . . *Ans.* .892.
14. Find the square root of .3478312. . . *Ans.* .5897’.
15. Find the square root of 737.8742. . . *Ans.* 27.16’.
16. Find the square root of 43.73731. . . *Ans.* 6.613’.
17. Find the square root of .0073474. . . *Ans.* .0857’.
18. Find the square root of $\frac{2314}{4000}$. . . . . *Ans.* .7605’.
19. Find the square root of $\frac{7348}{8700}$. . . . . *Ans.* .919’.
20. Find the square root of $23734\frac{23}{100}$. . *Ans.* 154.059’.
21. Find the square root of $74786\frac{346}{1000}$. . *Ans.* 273.47’.
22. Find the square root of 90374376. . *Ans.* 9506.543’.
23. Find the square root of 23473783. . *Ans.* 4844.975’.
24. Find the square root of $847376\frac{31}{270}$. *Ans.* 920.530’.
25. Find the square root of $783703\frac{471}{385}$. *Ans.* 885.27’.

APPLICATION OF THE SQUARE ROOT.

§ 303. The *area* of a surface is equal to the product of its *length* into its *breadth;* using these dimensions in the *same denomination.*

Since a square has its length and breadth equal to each other, the *area of a square* is equal to either of its sides multiplied into itself; that is, the area of a square is the *square of either of its sides.*

Hence, the area of the square being given, a *side of the square* will be found by extracting the *square root of the area.*

EXERCISES.

26. How long must the side of a square lot be, which shall contain just one acre of ground? *Ans.* 12.649’*p.*

27. How long must the side of a square field be, which shall contain just 10 acres of ground? *Ans.* 40 poles.

28. What must be the side of a square, which shall be equal in area to a surface 320 *yd.* long, and 75 *yd.* wide? *Ans.* 154.919’*yd.*

29. A merchant bought a bale of cloth, containing just as many pieces as there were yards in each piece. The whole number of yards was 1089; what was the number of pieces? *Ans.* 33 pieces.

30. What must be the sides of two squares, one of which shall contain 2 square miles, and the other 3 square miles, of land? *Ans.* 452.548’*p.*; and 554.256’*p.*

31. A regiment consisting of 5476 men, is to be formed into a solid square. How many men must be placed in rank and file, that is, in a line on the front, and from front to rear?
Ans. 74 men.

32. What would be the expense of enclosing 15 *A.* 2 *R.* 18 *P.* of ground, in the form of a square, at the rate of $2.12½ per rod for the fencing? *Ans.* $424.82'.

33. A company of men on a journey expended $6084; each man expending as many dollars as there were men in the company. What was the number of men? *Ans.* 78 men.

34. A farmer wishes to plant an orchard which shall contain 8464 trees, and have as many rows of trees as trees in each row. What will be the number of trees in each row?
Ans. 92 trees.

35. A city whose corporate area is in the form of a circle, contains 3.1416 square miles, and is 6.2832 miles in circumference. Had the same amount of area been incorporated in the form of a square, what would have been the compass of the city? *Ans.* 7.088' miles.

36. What must be the dimensions of a field to contain 10 acres of ground, and have its length equal to twice its breadth?

One half of the given area will be the area of a *square*, whose size is equal to the breadth of the field.
Ans. 28.284'*p.* in breadth; 56.568'*p.* in length.

37. A garden which shall contain an acre of ground, is to have its breadth equal to one half of its length. What must be its dimensions?
Ans. 8.944'*p.* in breadth; 17.888'*p.* in length.

38. A cemetery containing 15 acres is laid out in such a manner that its length is equal to three times its breadth. What are the dimensions of the cemetery?
Ans. 28.284'*p.* in breadth; 84.852'*p.* length.

39. A warehouse whose base shall occupy 10000 square feet, is intended to have its breadth only one-third of its length. What must be the length and breadth?
Ans. 173.205'*ft.* by 57.735'*ft.*

40. A farmer intending to enclose 50 acres of land, wishes to know what difference in the amount of fencing there would be between having the enclosure in the form of a square, and having it such that its length shall be double its breadth?
Ans. 21.702' poles.

Extraction of the Cube Root.

The following principles form the basis of the Rule for extracting the cube root.

§ 304. I. The cube of a number has, at most, only *three times* as many, and, at least, *only two less than three times* as many figures, as the number itself.

Thus, $99^3=970299$; $999^3=997002999$; in which examples, the cubes have only three times as many figures as the respective numbers or roots, and those numbers are the largest that can be expressed by the same number of figures.

Again, $10^3=1000$; $100^3=1000000$; in which the cubes have only two less than three times as many figures as the numbers or roots, and those numbers are the smallest that can be expressed by the same number of figures.

From the preceding, it follows that

§ 305. II. A number has *three figures* for each figure in its *cube root*, excepting the left hand one—for which it has one, two, or three figures, according as said left hand figure produces one, two, or three figures, in *cubing the root.*

§ 306. III. If a number be divided into any two parts, the *cube of the number* will be equal to the *cube* of the 1*st part*, + 3 times the *square* of the 1*st into the* 2*d*, + 3 *times the first into the* $2d^2$, + the *cube of the* 2*d part.*

For example, $16=10+6$, and the *cube* of 16 = the *cube* of $(10+6)$.

The square of 16, equal to the square of $(10+6)$ as heretofore found,

$$\begin{array}{r} \text{is } 100+\ 120+\ 36 \\ 10+\ \ 6 \\ \hline 600+\ 720+216 \\ 1000+1200+\ 360 \\ \hline 1000+1800+1080+216 \end{array}$$

= the cube of $(10+6)=16^3$.

The square of $(10+6)$ multiplied by $(10+6)$, produces the cube of $(10+6)$.

Multiplying, we have $36\times6=216$; $120\times6=720$; and $100\times6=600$; also, $36\times10=360$; $120\times10=1200$; and $100\times10=1000$.

The sum of all these products is equal to $1000+1800+1080+216=16^3$.

This cube is composed of $10^3=1000$; 3 times $10^2\times6=1800$; 3 times $10\times6^2=1080$; and $6^3=216$.

RULE LVIII.

§ 307. *To extract the* CUBE ROOT *of a given number.*

1. Separate the given number into periods of three figures each, from right to left; observing that the last period may sometimes have but one or two figures.

2. From the left hand period subtract the greatest cube number it contains, and set the root of said cube for the first figure of the root required.

3. To the remainder affix the next period for a dividend. Divide this dividend, exclusive of its two right hand figures, by three times the square of the root already found, taken as an *incomplete divisor*, and annex the quotient figure to the root.

4. *Complete the divisor* by annexing to it two 0s, and adding three times the product of the last quotient figure into the previous root with a 0 annexed, and also the square of the last quotient figure.

5. Multiply the divisor thus completed by the last quotient figure; subtract the product from the dividend; to the remainder affix the next period for a dividend; divide by three times the square of the root already found, and so on, as before, until the operation is completed.

In applying this Rule it will be convenient to refer to the following

Table of Roots and Cubes.

ROOTS.	CUBES.	ROOTS.	CUBES.	ROOTS.	CUBES.
1	1	4	64	7	343
2	8	5	125	8	512
3	27	6	216	9	729

EXAMPLE.

1. To extract the cube root of 91125.

$$\begin{array}{r|l} & 91'125(45 \\ & 64 \\ \hline 48 & 27125 \\ 4800+600+25=5425 & 27125 \end{array} \qquad 91125^{\frac{1}{3}}=45.$$

The left hand period is 91, and the greatest cube number it contains is 64, the root of which is 4. Subtracting, and to the remainder 27 affixing the next period, we have for a dividend 27125.

Excluding the two right hand figures, we divide 271 by 48, which is 3 times 16, the square of the root 4 already found, and annex the quotient figure 5 to the root.

To complete the divisor 48, we annex two 0s, making 4800, and add 600, which is 3 times 200, the product of the last quotient figure 5 into 40, the previous root 4 with a 0 annexed, and add also 25, the square of 5.

The divisor thus completed is 5425, which, multiplied by 5, equals the dividend.

2. To extract the cube root of 223648543.

$$\begin{array}{r|l} 108 & 223'648'543(607 \\ & 216 \\ \hline 10800 & \ \ 7648543 \\ 1080000+12600+49=1092649 & \ \ 7648543 \end{array}$$

The left hand period is 223, and the greatest cube number it contains is 216, the root of which is 6. Subtracting, and to the remainder 7 affixing the next period, we have for a dividend 7648.

Excluding the two right hand figures, we divide 76 by 108, which is 3 times 36, the square of the root 6 already found. The quotient figure is 0. We annex 0 to the root, and affix the next period, obtaining a new dividend 7648543.

☞ The given number is separated into periods, to determine the number of figures in the root, and also whether one, two, or three figures on the left, correspond to the first figure in the root. (§ 305).

In the 1st example, the first figure 4 in the root, is 4 *tens* $=40$; and its cube $=64000$, which, subtracted, leaves the remainder 27125.

The given number $91125=4$ *tens*$^3+3\times4$ *tens*$^2\times$ the *units* of the root, $+3\times4$ *tens* $\times$ the *units*^{2}, $+$ the *units*^{3}. (§ 306).

And since 4 tens^3 has been subtracted, the remainder $27125=3\times4$ *tens*$^2\times$ the *units*, $+3\times4$ *tens* $\times$ the *units*, $^2+$ the *units*^{3}.

In taking $48=3\times4^2$ for an incomplete divisor, we omitted two 0s in the right of 4 *tens*^{2}. Omitting, therefore, the 25 in the corresponding places of the dividend 27125, we say 48 in 271, 5 times.

Regarding now the quotient 5 as the *units* to be found in the root, the completed divisor $4800+600+25$ is 3×4 *tens*$^2+3\times4$ *tens* $\times5$ *units* $+5$ *units*^{2}; and this divisor multiplied by $5=3\times4$ *tens*$^2\times5$ *units*, $+$ 3×4 *tens* $\times5$ *units*^{2}, $+5$ *units*^{3}; $=27125$; and this added to 4 *tens*^{3} makes up the given number.

Hence the given number $91125=(4$ *tens* $+5$ *units*$)^3=45^3$; (§ 306), hence also, the root is correctly found by the Rule.☜

Note. The quotient figure—being found from an *incomplete divisor*—will often be a *unit or two* less than the number of times such divisor is contained in those figures of the dividend, which are taken in dividing.

EXERCISES.

1. Find the cube root of 59319. . . . . *Ans.* 39.
2. Find the cube root of 103823. . . . . . *Ans.* 47.
3. Find the cube root of 262144. . . . . . *Ans.* 64.
4. Find the cube root of 2406104. . . . . *Ans.* 134.
5. Find the cube root of 22906304. . . . . . *Ans.* 284.
6. Find the cube root of $\frac{19683}{389017}$. . . . . . . *Ans.* $\frac{27}{73}$.
7. Find the cube root of $\frac{132651}{25672375}$. . . . . . *Ans.* $\frac{51}{295}$.

A more convenient method of forming the Divisors, in Extracting the Cube Root.

§ 308. For the *first incomplete divisor*, take 3 times the square of the first figure in the root; and with this divisor find the second figure, as before.

Complete the divisor by annexing to it two 0s, and adding the product of the last figure in the root with 3 times the other part of the root prefixed to it, multiplied by the last figure.

Each succeeding incomplete divisor will be found by adding to the last complete divisor, the *product which completed it,* and the *square of the last figure* in the root. The divisors are all completed in the same manner.

EXAMPLE.

To extract the cube root of 95443993.

```
                        |95'443'993(457
                        |64
                        |-------
                      48|31443
          4800+625=5425 |27125
                        |-------
      5425+625+25=6075  | 4318993
   607500+9499=616999   | 4318993
```

The first incomplete divisor is 48, equal to 3 times 16, the square of 4,—which divisor gives the quotient 5, the second figure in the root.

To complete the divisor 48, we annex to it two 0s, and add 625, which is the product of 125, (that is, 5 with three times 4 prefixed to it), multiplied by 5. The divisor thus completed is 5425.

For the next incomplete divisor, we add to the last complete divisor the product 625 which completed it, and 25, the square of 5.

Having found the quotient 7, we complete the divisor 6075 by annexing to it two 0s, and adding 9499, which is the product of 1357, (that is, 7 with three times 45 prefixed to it), multiplied by 7. The divisor thus completed is 616999.

☞ This method of forming the divisors, involves the same principle, (§ 306,) with the Rule before given.

Thus, the 625 added to complete the first divisor is $125\times5=(120+5)\times5=120\times5+5^2=3$ times $40\times5+5^2$.

And the incomplete divisor $6075=4800+625+625+25=3$ times $40^2,+3$ times $40\times5+5^2,+3$ times $40\times5+5^2,+5^2=3$ times 40^2+6 times $40\times5+3$ times $5^2=3$ times $(40^2+$ *twice* $40\times5+5^2)=3$ times 45^2.

The divisors are, therefore, the same as required by the Rule. (§307.) ☜

EXERCISES.

8. Find the cube root of 20796875. . . . . *Ans.* 275.
9. Find the cube root of 28372625. . . . . *Ans.* 305.
10. Find the cube root of 69934528. . . . . *Ans.* 412.
11. Find the cube root of 91125000. . . . . *Ans.* 450.
12. Find the cube root of 125000000. . . . . *Ans.* 500.
13. Find the cube root of 131872229. . . . . *Ans.* 509.
14. Find the cube root of 241804367. . . . . *Ans.* 623.
15. Find the cube root of 997002999. . . . . *Ans.* 999.

Cube Root of Decimals, Imperfect Cubes, &c.

§ **309.** In extracting the cube root, an *integer* is separated into periods from *right* to *left*. A *decimal* must be separated into periods of three figures each, from the *decimal point towards the right;* and one or two 0s must be annexed when necessary to complete the last period.

The number of *decimal figures* in the root, must be the same as the number of *periods* in the given decimal.

In finding the root of an imperfect cube, (§ 292), a period of 0s may be annexed to the last remainder, and the operation continued in this manner to any required exactness; observing that each period thus annexed must be counted as a decimal period belonging to the given number.

A fraction will be an *imperfect cube*, if either of its terms is an imperfect cube. Its root in such case will be found, most readily, by extracting the root of its *equivalent decimal.*

A *vulgar fraction* annexed to an integer may be reduced to a decimal, and the root of the mixed number be then extracted.

The product of three decimal fractions, contains just as many decimal figures as all the three factors. The cube of a decimal fraction has, therefore, three times as many decimal figures as the decimal itself Hence each decimal *period* must contain *three figures*; and the number of decimal figures in the root, must equal the number of decimal periods.

EXERCISES.

16. Find the cube root of .389017. . . . . *Ans.* .73.
17. Find the cube root of .202262003. . . *Ans.* .587.
18. Find the cube root of .23456. . . . . *Ans.* .616'.
19. Find the cube root of 734.673. . . . . *Ans.* 9.023'.
20. Find the cube root of 7386. . . . . . *Ans.* 19.474'.
21. Find the cube root of $9873\frac{1}{4}$. . . . . *Ans.* 21.452'.
22. Find the cube root of $7370\frac{2}{3}$. . . . . *Ans.* 19.461'.
23. Find the cube root of 479.2735. . . . *Ans.* 7.825'.
24. Find the cube root of $8377\frac{23}{150}$. . . . *Ans.* 20.309'.

APPLICATION OF THE CUBE ROOT.

§ 310. The *solidity* or *volume* of a body, in cubic measure, is equal to the product of its *length* into its *breadth* into its *height* or thickness.

Since a *cube* has its length, breadth, and thickness, equal to one another, its solidity is equal to the cube of either of its three sides or dimensions.

Hence, the solidity of a cube being given, either of its three dimensions will be found by extracting the *cube root of its solidity*.

EXERCISES.

25. What must be the length, breadth, or height of a cube, that its volume or solidity may be 1728 cubic feet?
Ans. 12 feet.

26. What must be the length, breadth, or depth, of a cubical box, that its capacity may be 2000 cubic feet?
Ans. 12.598'*ft.*

27. What must be the depth of a cubical cistern which shall contain 5000 gallons of water? Of one to contain 500 barrels? *Ans.* 9.344'*ft.*; 14.321'*ft.*

28. What must be the dimensions of a cubical granary which shall contain 3000 bushels of wheat? One to contain 10000 bushels? *Ans.* 15.513'*ft.*; 23.173'*ft.*

29. What must be the dimensions of a cubical cellar whose capacity shall be equal to that of another 30 feet long, 20 feet wide, and $10\frac{1}{2}$ feet deep? *Ans.* 18.469'*ft.*

30. The solidity of a cubical block of marble is 1331 cubic

feet. What is the length of the block, and the area of its surface? *Ans.* 11 *ft.*; area 726 *sq. ft.*

31. A cubical cistern is to be constructed which shall contain 300 barrels of water; the bottom and walls of which are to be plastered with hydraulic lime. How many square yards of plastering will there be? *Ans.* 81.056' *sq. yd.*

32. A farmer wishes to construct a crib whose capacity shall be 2000 bushels,—its breadth and height to be equal, and each of these one half of its length. What must be the length of the crib? *Ans.* 21.512' *ft.*

33. How many square feet of plank will be required to line a reservoir, open at the top, the capacity of which is to be 10000 gallons of water, and the length, breadth, and depth, equal to one another? *Ans.* 693.017' *sq. ft.*

34. The capacity of the reservoir being as in the preceding question, how many feet of plank would be required to line it, allowing its length to be double each of its other dimensions? *Ans.* 698.482' *sq. ft.*

Extraction of any Root whatever of a Given Number.

Any root whatever of a given number might be extracted—by finding the first figure in the root—with this figure, forming an incomplete divisor—with the quotient figure and the preceding part of the root, completing the divisor—and so on, in a manner dependent on the *order* of the root to be found.

But this method, which is preferable for the *square* and *cube*, becomes too complicated when applied to other roots. By dispensing with the complete divisors, the operation may be simplified, and the process of evolution *generalized*, as follows:

RULE LIX.

§ **311.** *To extract any required root of a given number.*

1. Separate the given number into periods of *two*, *three*, or *four*, &c., figures each—according to the *order of the root* required—from right to left.

2. From the left hand period subtract the greatest *power*, of the corresponding order, that is contained in it; and set the root of said power for the first figure of the root required.

3. To the remainder affix the first figure of the next period, for a dividend, and,
for the 2*d* *root*, divide by 2 × 1*st power* of the root already found;
for the 3*d* *root*, divide by 3 × 2*d* *power* of the root already found;
for the 4*th root*, divide by 4 × 3*d* *power* of the root already found;
and so on,—annexing the quotient figure to the root.

4. Subtract the corresponding power of the root now found from the two left hand periods of the given number; and to the remainder affix the first figure of the next period, for a dividend.

5. From the root already found, form a divisor as before; and so on, until the evolution is completed.

EXAMPLE.

To extract the 4th root of 3049800625.

$$
\begin{array}{rl}
 & 30'4980'0625(235 \\
 & \underline{16} \\
4\times2^3=32) & \underline{144} \\
23^4= & \underline{279841} \\
4\times23^3=48668) & \underline{251390} \\
235^3= & 3049800625
\end{array}
$$

The given number is separated into periods of *four* figures each, because the 4th *root* is to be extracted. The greatest 4th *power* in 30 is 16, the root of which is 2, &c.

§ **312.** A root whose *exponent is resolvable into two factors*, may be found by extracting such a root of the given number as is denoted by *one of those factors*, and then such a root of *that root* as is denoted by the other.

Thus the 4th root may be found by extracting the *square root* of the *square root*. $256=16\times16$; and $16=4\times4$; that is, $256^{\frac{1}{2}}=16$, and $16^{\frac{1}{2}}=4$; and 256 being thus equal to $4\times4\times4\times4$, the 4th root of 256 is 4.

In like manner, the 6th root is equal to the *cube root* of the *square root*, or the square root of the cube root; and so on.

Note. In common Arithmetic we seldom or never have occasion to employ any other than the square and cube roots; and these are most readily found by the former Rules. No exercises are therefore given for the last Rule.

EXERCISES ON CHAPTER XII.

1. Find the square, and also the square root of 284.
Ans. Square 80656; square root, 16.852'

2. Find the square, and also the square root of 3.26.
Ans. Square, 10.6276; square root, 1.8055'

3. Find the square, and also the square root of 7.52.
Ans. Square, 56.5504; square root, 2.7422

4. Find the square, and also the square root of 83.9.
Ans. Square, 7039.21; square root, 9.159

5. Find the square, and also the square root of 90.8.
Ans. Square, 8244.64; square root, 9.528

6. Find the square, and also the square root of .947.
Ans. Square, .896809; square root, .973'

7. Find the square, and also the square root of $\frac{9}{256}$.
Ans. Square, $\frac{81}{65536}$; square root, $\frac{3}{16}$

8. Find the square, and also the square root of $\frac{25}{231}$.
Ans. Square, $\frac{625}{53361}$; square root, .328.

9. Find the square, and also the square root of $235\frac{1}{4}$.
Ans. Square, $55342\frac{9}{16}$; square root, 15.337'.

10. Find the square, and also the square root of $476\frac{2}{3}$.
Ans. Square, $227211\frac{1}{9}$; square root, 21.832'.

11. Find the cube, and also the cube root of 165.
Ans. Cube, 4492125; cube root, 5.484'.

12. Find the cube, and also the cube root of 27.4.
Ans. Cube, 20570.824; cube root, 3.014'.

13. Find the cube, and also the cube root of 3.28.
Ans. Cube, 35.287552; cube root, 1.485'.

14. Find the cube, and also the cube root of .463.
Ans. Cube, .099252847; cube root, .773'.

15. Find the cube and also the cube root of $125\frac{1}{2}$.
Ans. Cube, $1976656\frac{3}{8}$; cube root, 5.006'.

16. How many rods of fence will be required to enclose 10 acres of ground, in the form of a square? *Ans.* 160 rods.

17. How many rods of fence would be required to enclose a field containing 15 *A.* 2 *R.* 20 *P.*, and having its length equal to twice its breadth? *Ans.* 212.130' rods.

18. A farmer has two tracts of land containing the same number of acres. One of the tracts is a square which is 10000 rods in compass, and the other an oblong whose breadth

is one-third of its length; required the dimensions of the latter. *Ans.* Length 173.205', breadth 57.735' rods.

19. How many square feet of plank would be required to line the four sides of a cubical cistern which shall contain 500 barrels of water? *Ans.* 820.364' *sq. ft.*

20. A granary whose capacity is 3000 bushels, has its length equal to twice its breadth or height. What are the dimensions of the granary?
Ans. Breadth or height 12.312', length 24.624'*ft.*

21. Another granary whose capacity is 5000 bushels, has its length equal to twice its height, and its height equal to twice its breadth. What are its dimensions?
Ans. Breadth 11.586', height 23.172', length 46.344'.

22. A certain orchard contains 822649 trees, and the number of rows of trees is equal to the number of trees in each row Required the number of rows. *Ans.* 907.

23. A bale of linen contained 1521 yards, and the number of pieces in it was equal to the number of yards in each piece. How many pieces were there? *Ans.* 39.

24. A farmer wishes to know what must be the depth of a cubical box which shall contain 100 bushels of grain.
Ans. 4.992'*ft.*

25. A gentleman has an oblong garden 40 poles in length, and 23*p.* in breadth. Intending to reduce it to the form of a square, of the same area, he wishes to know what must be the length of each side. *Ans.* 30 331'*p.*

26. A certain reservoir for water is 150*ft.* in length, 100*ft.* in breadth, and 20*ft.* in depth, and is lined at the bottom and sides with plank which cost $1.50 per 100*sq. ft.* Had the reservoir been in the form of a cube of equal capacity, what would have been gained or lost in the cost of the plank for lining it? *Ans.* $38.898' gained.

THE END.

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